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CENTRAL
RICE RESEARCH INSTITUTE
CUTTACK (INDIA)

TECHNICAL REPORT
FOR
THE YEAR 1961

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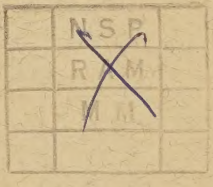

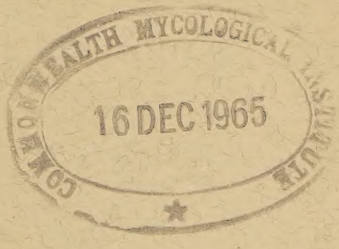

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TECHNICAL REPORT FOR THE YEAR 1961

AGRONOMY

Weather and crop conditions

The monsoon set in quite early this year and there was a total precipitation of 1978.7 mms. (77.90") as against the normal of 1546.1 mms. (58.87"). The rainfall was far in excess of the normal in the months of June, July and September as a result of which the preparation of nursery was abnormally delayed. Following a heavy and continuous downpour of 476.8 mms. (18.77") for 48 hours during 5th to 7th September, 1961, the accumulated water from the catchment areas caused inundation of standing crops. The level of water varied from 2' to 7' according to the topography of land and the the crop remained submerged for 3 to 7 days. The early duration varieties planted in early July were not affected by this inundation while the medium and late duration varieties of rice which were planted in later part of August were very badly damaged, so much so many experiments had to be retransplanted in late September after the flood water receeded. The general yields of the crop, both experimental and bulk, were poor and erratic. The distribution of rainfall along with other meteorological data are given in Tables I and II below :

TABLE I

Rainfall in mms. and inches during the year 1961 *as compared to the average of last ten years*

Monsoon	Months	Normal rainfall in mms. (average of ten years		Rainfall in 1961		Deviation from the mean	
		mms.	inches	mms.	inches	mms.	inches
Winter	January	9·9	0·39	38·3	1·51	+28·4	+1·12
	February	19·3	0·76	111·0	4·37	+91·7	+3·61
	TOTAL	29·2	1·15	149·3	5·88	+120·1	+4·73
Pre-monsoon	March	21·3	0·84	0·0	0·00	—21·3	—0·84
	April	23·9	0·94	0·0	0·00	—23·9	—0·94
	May	66·8	2·63	121·1	4·77	+54·3	+2·14
	TOTAL	112·0	4·41	121·1	4·77	+9·1	+0·36
S. W. Monsoon	June	172·0	6·77	264·5	10·41	+92·5	+3·64
	July	247·9	9·76	415·9	16·37	+168·0	+6·61
	August	357·6	14·08	284·0	11·18	—73·6	—2·90
	September	309·6	12·19	593·9	23·38	+284·3	+11·19
	TOTAL	1087·1	42·80	1558·3	61·34	+471·2	+18·54
Post Monsoon	October	244·6	9·63	150·0	5·91	—94·6	—3·72
	November	72·4	2·85	0·0	0·00	—72·4	—2·85
	December	0·8	0·03	0·0	0·00	—0·8	—0·03
	TOTAL	317·8	12·51	150·0	5·91	—167·8	—6·60

TABLE II

Meteorological data for the year 1961

Monsoon	Months	No. of rainy days	Maximum temperature °C	Minimum temperature °C	Mean temperature of the day	Humidity 7 A.M.	Humidity 2 P.M.	Mean Humidity of the day	Hours of bright sunshine
Winter	January	4	27·1	15·2	21·1	93	53	73	8·1
	February	7	27·4	16·3	21·9	90	54	72	7·9
	TOTAL	11	..	..	..	..	..	..	..
Pre-monsoon	March	Nil	34·1	23·4	28·7	91	47	69	8·1
	April	Nil	38·1	25·1	31·6	86	37	61	8·8
	May	7	38·2	26·5	32·3	86	49	67	8·8
	TOTAL	7	..	..	..	..	..	..	..
S. W. monsoon	June	16	34·0	26·0	30·0	89	72	81	5·2
	July	19	30·3	25·3	27·8	92	83	88	3·5
	August	23	32·0	25·7	28·9	93	85	89	3·3
	September	20	30·9	25·3	28·1	93	83	89	3·1
	TOTAL	78	..	..	..	..	..	..	..
Post-monsoon	October	13	31·0	23·3	27·1	92	75	83	7·3
	November	Nil	28·1	17·4	22·7	87	59	73	8·9
	December	Nil	26·0	11·8	18·9	86	45	66	9·9
	TOTAL	13	..	..	..	..	..	..	..

There was no severe outbreak of any pest and disease but as a prophylactic measure the crops were sprayed with insecticides and fungicides. Following the inundation of the crop as mentioned above, the crops in some of the fields turned yellow and never recovered later on.

I. *Varietal Trials*

The yield performance of 125 varieties grouped under different maturity periods was tested in six varietal trials. Besides, 164 types were grown in the main season under observation plots to determine their performance and for maintenance.

In the trial of varieties maturing within 100 days, twelve varieties were tested against the control CH. 2. The variety ADT-3 recorded the highest grain yield of 1886 Kg/Ha which was 28 percent more than the control CH. 2 which yielded 1475 Kg/Ha. The varieties CH. 10, D.204-1, DCA-14 and CH. 42 yielding 1783, 1770, 1639 and 1527 Kg/Ha respectively were not significantly superior to control.

In the trial of varieties maturing within 100-110 days, eighteen varieties were tried against the local standards Benibhog and PTB. 10. Six out of fifteen coarse grained varieties *viz.*, W. 689, W. 348, BM. No. 5, HR-19, JBS. 27 and AC. 503 were at par with the control, PTB. 10 which yielded 2257 Kg/Ha. Among fine grained varieties SLO. 16 recorded the highest yield of 1743 Kg/Ha but it was statistically at par with the control Benibhog which yielded 1480 Kg/Ha.

In the trial of varieties maturing within 110-120 days, out of twenty varieties tried in this group, none of them was found superior to the control BAM-12 which recorded the grain yield of 2188 Kg/Ha. However, only four varieties *viz.*, B. 76-1, CH. 13, JBS. 152 and EHM-7-13-43-95 were statistically at par with the control and the rest were significantly inferior.

In another trial with varieties maturing within 120—130 days, 22 hybrid cultures received from Botany Division and 8 other types were tried against two controls, T. 635, and T. 608, the former being coarse grained and the latter being superfine. Among coarse ones, varieties Co. 25 × Co. 13-562-31-56-3-22, W-714, AC. 3997 and Co. 25 × Co-13-562-31-56-3-29 were found quite promising with grain yields of 2918, 2431, 2387 and 2288 Kg/Ha respectively as against the control yield of 1403 Kg/Ha. Among fine grained ones only two cultures *viz.*, EHF-161-303-73-34-66 and EHF-161-303-73-46-68-73 were found significantly better than that of control (T. 608) which recorded grain yield of 1460 Kg/Ha.

Twenty one medium duration varieties maturing within 130-150 days including some *japonica* × *indica* hybrids were tried in a varietal trial. None of the varieties was found to be significantly superior to that of the control T. 141 and T. 1145 which recorded grain yields of 1681 and 1298 Kg/Ha. respectively. However, all the *japonica* × *indica* hybrids were statistically at par with the controls.

The late duration varietal trial was badly damaged due to prolonged submergence before the crop established well after transplanting. The experiment had to be abandoned.

Sixteen promising early varieties were tried for their suitability for the second crop season in a replicated varietal trial. The variety PTB. 10 was used as standard. The variety PLA. 1 produced a grain yield of 2929 Kg/Ha which was significantly superior to the control which yielded 2469 Kg/Ha. The varieties Tepa. I, CB. II and BJ. 1 which yielded 2627, 2484 and 2301 Kg/Ha. respectively were statistically at par with the control. Results are in conformity with the previous years.

Besides, forty-five 'Dalua' types were grown in the second season (December to April) under observation plot to determine their suitability and performance.

II. *Variety* × *Manure Interaction*

Early Varieties × *Spacing* × *Nitrogen:*

To study the differential response of early duration varieties to different spacings and levels of nitrogen, two varieties *viz.*, PTB. 10 (high tillering) and N. 136 (low tillering) were tried with four spacings, 15 cm. × 7.5 cm., 15 cm. × 15 cm., 15 cm. × 22.5 cm. and 15 cm. × 30 cm., under four levels of N *i. e.* 0, 33, 66 and 99 Kg N/Ha. in a split plot design with levels of nitrogen in the main plot and varieties × spacing in the sub-plot. This experiment was

initiated during the year 1959 and was repeated for the third year in succession. As in previous years, none of the factors showed significant difference so far the grain yields are concerned.

Medium varieties × *Nitrogen :*

To study the differential response of medium duration varieties of rice to increasing doses N, six varieties (duration being 120-145 days) *viz.*, T. 141, T. 61, T. 378, RDR-4, Untung-588 and J×I-431-32-23-17 were tried under five different levels of N. The experiment was conducted in a split plot design with level of N in the main plot and the varieties in the sub-plot. The yield of grain obtained is presented in Table III.

TABLE III

Medium varieties × *Nitrogen*

Yield of grain in Kg/Ha

Nitrogen levels / Varieties	NO	N22	N44	N66	N88	Mean
T. 141	1310	1838	2275	2502	2967	2178
T. 61	844	1205	1593	2251	1939	1566
T. 378	397	458	665	878	838	647
RDR-4	532	1021	931	1618	663	953
U. 588	616	627	931	1405	1431	1002
JI. 431	922	1620	2654	2844	3114	2231
Mean	770	1128	1508	1916	1825	

C. D. (0·05) to compare Nitrogen means = 372
C. D. (0·05) to compare Variety means = 201
C. D. (0·05) to compare N means within a variety = 554
C. D. (0·05) to compare Variety means within N = 449

The data presented in the above table showed that the interactions between varieties and nitrogen were statistically significant. Of the six varieties tried in the experiment only one variety T. 378 did not show any differential response due to increase in levels of nitrogen. The varieties T. 141 and J×I-431-32-23-17 showed linear increase in yield upto 88 Kg N/Ha. while the varieties T. 61, RDR-4 and U. 588 gave maximum yield at 66 Kg N/Ha.

The differences due to levels of nitrogen and varieties were also statistically significant. With the increase in the level of nitrogen upto 66 Kg N/Ha. the yields increased linearly beyond which the yields were depressed. The differences between no manure control and 22 Kg N/Ha. were not significant.

Among the varieties the only *japonica* × *indica* hybrid (J×I-431-32-23-17) gave the highest grain yield of 2231 Kg/Ha. which was immediately followed by the popular local variety T. 141 with a grain yield of 2178 Kg/Ha. Rest of the varieties were significantly inferior to J×I-431-32-23-17 and T. 141.

Medium varieties × Nitrogen × Phosphorus :

Five medium duration varieties *viz.*, T. 141, T. 1759, W. 105, BAM. 3 and J × I-679-36-48-39 were tried with eight treatment combination of nitrogen and phosphorus (0,33,66 and 99 Kg N/Ha × 0 and 56 Kg. P_2O_5/Ha.) to study the differential response of varieties. The entire dose of P_2O_5 was applied at the time of planting whereas nitrogen was applied in two splits, one half at the time of planting and the other half applied two weeks before flowering. The yields of grain obtained are presented in Tables IV (a) and (b) below :

TABLE IV (*a*)

Medium varieties × N × P

Yield of grain in Kg/Ha

Fertilizers / Varieties	Levels of N & P in Kg/Ha								Mean
	NO		N33		N66		N99		
	PO	P55	PO	P55	PO	P55	PO	P55	
T. 141 . . .	1551	1482	2379	2211	2037	1615	1546	1993	1976
T. 1759 . . .	1026	1499	1553	1890	2307	1834	1299	1523	1616
W. 105 . . .	1294	1708	1672	1983	2112	1682	1672	1291	1677
BAM. 3 . . .	1201	1579	962	1602	1384	1680	895	1127	1304
JI. 679-36-48-39 . .	1564	1811	1782	1780	1525	1957	1219	1489	1641
Mean . . .	1327	1616	1670	1893	1873	1954	1326	1483	..

TABLE IV (*b*)

Medium varieties × N × P

Yield of grain in Kg/Ha

Varieties	Levels of nitrogen in Kg/Ha				Mean
	NO	N33	N66	N99	
T. 141	1517	2295	2326	1765	1976
T. 1759	1263	1722	2071	1411	1616
W. 105	1501	1328	1897	1482	1677
BAM. 3	1390	1282	1532	1011	1304
JI-679-36-48-39	1688	1781	1741	1354	1641
Mean	1472	1782	1914	1405	..

1. S. E. of N means	±112*
C. D. (0·05) per hectare for comparing N means	376
2. S. E. of P means	±79
3. S. E. of variety means	±79**
C. D. (0·05) per hectare for comparing variety means	227
4. S. E. of N means within a variety	±180
5. S. E. of P means within a variety	±128
6. S. E. of variety means within same level of N	±158
7. S. E. of variety means within same level of P	±112

The results presented in the above table showed that while the differences due to nitrogen application and varieties were significant the interactions between varieties × nitrogen, varieties × phosphorus and nitrogen × phosphorus were not significant.

Among four levels of nitrogen tried, 66 Kg N/Ha. gave the highest grain yield of 1914 Kg/Ha. which was significantly superior to that of 0, 33 and 99 Kg N/Ha. The highest dose of nitrogen *i. e.* 99 Kg/Ha significantly depressed the yield. Among the varieties, T. 141 gave the highest grain yield of 1976 Kg/Ha. followed by W. 105, J×I-679-36-48-39 and T. 1759 with grain yields of 1677, 1641 and 1616 Kg/Ha. respectively.

Late varieties × Nitrogen :

Experiments on late varieties × nitrogen and late varieties × time of application of nitrogen had to be abandoned due to the severe damage caused by the September flood.

III. *Manurial Trials*

Efficiency of nitrogenous fertilizers :

The experiment was conducted to test the relative efficiency of nine different forms of nitrogenous fertilizers with a no-manure control. The fertilizers were applied @ 33 and 66 Kg N/Ha. one half at the time of planting and the other half two weeks before flowering. The yields obtained with different nitrogenous fertilizers are given in Table V below :

TABLE V

Efficiency of nitrogenous fertilizers

Yield of grain in Kg/Ha

Sl. No.	Fertilizers	Level of N		Mean	% over control
		33 Kg N/ Ha	66 Kg N/ Ha		
1	Ammonium Sulphate Nitrate .	1449	1548	1499	176
2	Ammonium Chloride . . .	1059	1495	1277	150
3	Ammonium Sulphate . . .	1107	1369	1238	145
4	Urea Formaldehyde . . .	1097	1381	1239	145
5	Ammonium Phosphate . .	1118	1269	1194	140
6	Nitrophoska Blue . . .	954	1431	1193	140
7	Nitrophoska Green . . .	1081	1151	1116	131
8	Urea	1005	1167	1086	127
9	Calcium Ammonium Nitrate .	969	876	923	108
10	Ammonium Sulphate + Super Phosphate.	1048	1341	1195	140
11	Ammonium Sulphate + Potassium Sulphate.	1206	1249	1228	144
12	Ammonium Sulphate + Super phosphate+Potassium Sulphate.	1160	1377	1269	149
13	Control (no-manure) . . .	..	..	853	100

C. D. (0·05) per Hectare for levels = 137
C. D. (0·05) per Hectare for forms = 353
C. D. (0·05) per Hectare for interactions = 474.

The yields in general were very poor. Hence no definite conclusion could be drawn from this experiment. However, all the fertilizers gave higher grain yields over the no-manure control. So far the level of nitrogen is concerned, the yield obtained with 66 Kg/N/Ha. was significantly higher than that of 33 Kg N/Ha. which in turn was significantly better than the no-manure control. The responses obtained with ammonium sulphate nitrate, ammonium Chloride, ammonium sulphate, Urea formaldehyde and ammonium phosphate were 76, 50, 45, 45 and 40 percent higher respectively over the no-manure control.

Long range manurial experiments :

These experiments as previously reported, are designed to investigate the cumulative effect of continuous application of various fertilizers and manures on the soil productivity and the yield of rice.

(i) *Ammonium sulphate with and without lime and compost.*—This experiment has been in progress for the last fourteen years to study whether continuous application of ammonium sulphate in varying doses has any deleterious effect on the soil productivity and if so, whether it can be counteracted by the application of organic matter like compost and soil ameliorant like lime. Ammonium sulphate at O, 20 and 40 lb. N per acre (0, 22 and 44 Kg N/Ha) was being applied every year on the same plots with and without 100 mds. of compost as the basal dressing. Lime was applied once in three years at 0, 4 and 8 cwt. per acre (0, 5 and 10 quintals/Ha). The results are presented in Tables VI(a), (b) and (c) below :

TABLE VI (*a*)

Yield of grain in Kg/Ha

Variety T. 1145

Basal dressing of lime in cwt/acre	No compost				Compost @100 mds/ac.			
	NO	N22	N44	Mean	NO	N22	N44	Mean
LO . .	1500	2071	2325	1965	2093	2521	2832	2482
L4 . .	1470	1924	2162	1852	2086	2622	2953	2554
L8 . .	1475	1787	2246	1836	2194	2595	2928	2572
Mean . .	1482	1927	2244	1884	2124	2579	2904	2536

TABLE VI (*b*)

Yield of grain in Kg/Ha averaged over lime treatment

Compost / Level of N	CO	C100	Mean
NO	1482	2124	1803
N22	1927	2579	2253
N44	2244	2904	2574
Mean	1884	2536	

It would be seen from the data presented in Tables VI(a) and (b) that compost @ 100 mds. per acre gave significantly higher yields over no-compost treatment. Both the levels of nitrogen *i.e.* 22 and 44 Kg N/Ha as ammonium sulphate gave significantly higher yield over no-manure control. 44 Kg N/Ha was significantly superior to 22 Kg N/Ha.

TABLE VI (*c*)

Yield of grain Kg/Ha averaged over compost treatment

Basal dressing of lime in cwt/ac.	Level of N			
	NO	N22	N44	Mean
LO	1797	2296	2579	2224
L4	1778	2273	2558	2203
L8	1835	2191	2587	2204
Mean	1803	2253	2574	..

C. D. (0·05) per hectare for comparing compost means . . . . 234·86
C. D. (0·05) per hectare for comparing nitrogen means . . . . 124·54
S. Ed. per hectare for comparing compost means at the same level of nitrogen. ±77·26
S. Ed. per hectare for comparing N means at the same level of compost . ±106·47

The differences in grain yield due to lime application were not significant. This indicates that fourteen years of continuous application of Ammonium sulphate either alone or in combination with 100 mds. of compost did not bring about any deterioration of soil condition necessitating lime application.

(ii) *Ammonium Sulphate with and without compost.*—This experiment was conducted for the thirteenth year in succession on the same site. The results are given in Tables VII(a) and (b) below :

TABLE VII (*a*)

Yield of grain in Kg/Ha

Variety T. 1145

Top dressing of Amm. Sulphate	Basal dressing of compost		Mean
	C0	C100	
N0	1896	2329	2113
N22	2246	2989	2618
N44	2703	2925	2814
N66	2897	2999	2948
N88	2964	2911	2938
Mean	2541	2831	2686

C. D. (0·05) per hectare for comparing compost means . . . . =341
C. D. (0·05) per hectare for comparing N-means . . . . . =286
C. D. (0·05) per hectare for comparing compost means at the same level of N =377
C. D. (0·05) per hectare for comparing N means at the same level of compost =211

It might be seen from the data presented in Table VII(a) that control treatment has given the least yield while all the levels of nitrogen either alone or in combination with 100 mds. of compost have given significantly higher yield. The response due to application of compost is of the order of 290 Kg/Ha. but this difference fails to reach the level of significance. Among the levels of nitrogen 66 Kg N/Ha. has given the highest yield of 2948 Kg/Ha. after which there is depression in yield; but, all the levels of nitrogen *i.e.* 22, 44, 66 and 88 Kg/Ha (20, 40, 60 and 80 lb/A) have given significantly higher yield over N_0 level.

The interaction between compost and level of nitrogen is significant. In the no-compost series significant increase in grain yield was obtained upto 88 Kg N level. But the difference between 66 and 88 and between 44 and 66 Kg N levels were not significant. It is interesting to note that with every additional dose in the level of nitrogen the yield of grain has increased from O to 88 Kg N/Ha in a linear order. This was peculiar to this particular season. In the compost series highest significant yield was obtained at N 22 level, there being no difference between N 22, N 44, N 66 and N 88.

The yield nitrogen relationship could be represented by the quadratic curve as given by the equations.

No-Compost $Y = 1858.90 + 25.58 \times - 0.1416 X^2$

Compost $Y = 2401.98 + 25.25 \times - 0.4765 X^2$

where Y is the expected yield in Kg/Ha and X is the level of nitrogen. From the yield-N quadratic function, the estimated maximum yield of 2736 Kg/Ha and 3014 Kg/Ha were obtained with 26.43 and 90.32 Kg N/Ha in the form of ammonium sulphate with and without compost.

Residual effect.—To study the residual and cumulative effect of ammonium sulphate and compost applied continuously for eight years in the study mentioned above, each of the plots was divided into two equal halves and compost and ammonium sulphate were applied only to one half of the plots scheduled to receive the treatments. The results are given in Table VII(b) below :

TABLE VII (*b*)

Study of cumulative residual effect of Ammonium Sulphate and compost

Level of N as Ammonium sulphate	Levels of compost		C100-C0
	C0	C100	
N0	1548	2067	519
N22	1628	2022	394
N44	1543	2099	556
N66	1596	2090	494
N88	1553	2173	620
Mean	1574	2090	516

C. D. (0·05) per hectare for comparing compost means . . . . =325

It might be seen from the above table that there were no residual effects among the various levels of nitrogen both in the no-compost and compost series but the crop in the plots where compost was applied in previous years showed a cumulative effect to the tune of 516 Kg/Ha as compared to the no-compost treatment even during the fifth year of the residual study. The difference between the compost and no-compost treatment was found to be significant. Continuous application of ammonium sulphate @ 0, 22, 44, 66 and 88 Kg N/Ha did not give any beneficial or deleterious residuary effect.

(iii) *N. P. K. experiment.*—This experiment is designed to find a suitable combination of the major plant nutrients N, P and K when applied alone and in conjunction with compost. Ammonium sulphate was applied at 0, 44 and 88 Kg N/Ha (0, 40 and 80 lb N/Ac), Superphosphate at 0, 55 and 110 Kg P_2O_5/Ha (0, 50 and 100 lb P_2O_5/Ac) and Potassium sulphate at 0, 33 and 66 Kg K_2O/Ha (0, 30 and 60 lb K_2O/Ac). The basal dressing of compost was made at 22 Kg N/Ha (20 lb N/Ac). The yield data are given in Tables VIII(a) and (b) below :

TABLE VIII (*a*)

Yield of grain in Kg/Ha

Variety T. 1145

Top dressing of A/S in Kg/Ha	No compost	Compost	Mean
N0	1086	1211	1148
N44	1366	1508	1437
N88	1379	1660	1520
Mean	1277	1457	1368

C. D. (0·05) per comparing N means = 349

TABLE VIII (*b*)

Yield of grain in Kg/Ha

Level of K in Kg/Ha	Level of P_2O_5 in Kg/Ha			Mean
	P0	P55	P110	
K0	1423	1315	1363	1367
K33	1315	1427	1392	1378
K66	1377	1336	1367	1360
Mean	1372	1359	1374	..

It might be seen from the above tables that the yield has increased with every additional dose in the level of nitrogen from 0 to 88 Kg N/Ha. However, the difference in grain yield between 44 and 88. Kg N/Ha is not significant and only 88 Kg N/Ha gave a significant increase over No treatment. Compost application @ 22 Kg N/Ha increased the yield by 180 Kg over no-compost treatment. Statistical analysis of the data showed that the differences due to the application of P and K either alone or in combinations were not significant. This is in accordance with the findings of the earlier years.

Permanent manurial trial with recommended methods.—One permanent manurial trial initiated during the year 1959 with a view to compare the efficiency of compost and ammonium sulphate applied individually and in combination was repeated for the third year in succession. The treatments consisted of 44 Kg N/Ha applied either in the form of ammonium sulphate or compost and the combination of the two. The yields obtained with various treatments are presented in Table IX below :

TABLE IX

Sl. No.	Treatments	Yield in Kg/Ha	% over control
1	Control (no manure)	1512	100
2	44 Kg N/Ha as compost	1790	118
3	22 Kg N as compost + 22 Kg N/Ha as ammonium sulphate	1850	123
4	44 Kg N/Ha as ammonium sulphate	1998	132

C. D. (0·05) to compare treatment means =251 Kg/Ha.

The results show that all the manurial treatments *i.e.* compost and ammonium sulphate applied individually and in combination gave significantly higher yields over no-manure control. The highest grain yield of 1998 Kg/Ha was obtained in the treatment where only ammonium sulphate was applied @ 44 Kg N Ha but this treatment was statistically at par with the other two manurial treatments. These findings are in conformity with those of the previous years.

Experiment with Basic slag.—To study the efficacy of basic slag as a phosphatic fertilizer, a field experiment was initiated during the period under report. The basic slag, was tried @ 33 Kg P_2O_5/Ha alone and in combination with water hyacinth, raw cowdung, chaff straw and ammonium sulphate applied at the rate of 44 Kg N/Ha. The basic slag was obtained from the Hindusthan Steel Ltd., Rourkella Project, which was found to contain 3.6% P_2O_5. The grain yield data obtained from the various treatments are presented in the Table X below :

TABLE X

Experiment with Basic slag

Grain yield in Kg/Ha

Variety T. 141

Sl. No.	Basic slag / Source of N	Without Basic slag	With Basic slag (33 Kg P_2O_5/Ha)	Mean
1	Raw cowdung	1596	1758	1677
2	Rice straw (Chaff)	1705	1805	1755
3	Water Hyacinth	1506	1721	1614
4	Amm Sulphate	1848	2017	1951
5	No manure control	1212	1308	1260
	Mean	1573	1722	..

S. E. of treatment mean	±112**
C. D. (0·05) per hectare for comparing treatment means	323
S. E. of Basic slag mean	±50*
C. D. (0·05) per hectare for comparing Basic slag means	145
S. E. of source of N means	±79*
C. D. (0·05) per hectare for comparing source of N means	229

From the above table it might be seen that no-manure control has given the least yield of 1212 Kg/Ha. while all the rest of the manurial treatments have given significantly higher yields over no-manure control. It is interesting to note that the basic slag treatment (averaged over organic manures and inorganic fertilizers) has recorded a grain yield of 1722 Kg/Ha as against 1573 Kg/Ha in the treatment without basic slag and this difference is statistically significant. It is further seen that raw cowdung, rice straw, water hyacinth and ammonium sulphate have given distinctly higher yields in conjunction with basic slag over the treatments without basic slag. Among the organic manures and inorganic fertilizers, ammonium sulphate alone has recorded the highest yield of 1951 Kg/Ha followed by rice straw, raw-cowdung and water hyacinth with grain yields of 1755, 1677 and 1614 Kg/Ha respectively. This experiment throws some important light on the potential value of basic slag now going waste in all the steel plants of the country.

Experiment with paddy guard :

To find out the manurial value of paddy guard, a liquid received from Dr. S. L. Audich of Punjab under the instruction of Indian Council of Agricultural Research an experiment was laid out with four treatments including one no-manure control. The yields of grain obtained with different manurial treatments are presented in Table XI below :

TABLE XI

Sl. No.	Treatments	Yield in Kg/Ha	% over control
1.	No-manure control	2737	100
2.	33 Kg N/Ha as ammonium sulphate	3079	112
3.	Paddy-guard treated seedlings	3100	113
4.	33 Kg N/Ha as ammonium sulphate + paddy-guard treated seedlings.	3100	113

S. Ed. for comparing treatments = ±276

It might be seen from the above table that all the treatments have given higher yields over no-manure control. Paddy-guard treated seedlings alone have recorded as much yield as the treatment where an additional amount of 33 Kg N/Ha was added. There seems to be no difference between the treatments 33 Kg N/Ha alone and the paddy guard treated seedlings. However, the differences between the treatments were not statistically significant.

Study of the manurial value of indigenous products :

To study the manurial value of palm-gur molasses as compared to green manure, compost and sulphate of ammonia, a field experiment was carried out during the year 1960 and 1961. The experiments were conducted in a Randomized Block layout with four replications. The manures and fertilizer were applied at the rate of 33 Kg N/Ha. While green manure, compost and palm-gur molasses were applied as basal dressing, sulphate of ammonia was applied in two doses, one half at the final puddling and the other half one month after planting. Since the experiment was submerged, it was affected to a considerable extent as a result of which the whole experiment had to be retransplanted in the fourth week of September. Hence the yields in general are very poor. The yields of grain obtained are presented in Table XII below :

TABLE XII

Manurial value of indigenous products

Sl. No.	Treatments	Yield in Kg/Ha	% over control
1	Compost	1113	101
2	Green manure	1438	130
3	Ammonium sulphate	1543	140
4	Palm-gur molasses	1087	98
5	No manure-control	1106	100

C.D. (0·05) for comparing treatment means=342

The results presented above show that highest grain yield of 1543 Kg/Ha was obtained with ammonium sulphate followed by green manure treatment with a yield of 1438 Kg/Ha. Thus ammonium sulphate and green manure have given an increased yield of 40 and 30 per cent respectively over no-manure control. Application of palm-gur molasses gave lowest yield of grain. These findings are in conformity with those obtained during the year 1960. The probable reason of palm-gur molasses showing low response is the late application of this organic matter and consequent attraction of the insect pests which cause heavy mortality.

Trials with green manure crops.—After the termination of the scheme for the improvements of green manure crops for rice, financed by the Indian Council of Agricultural Research, forty-eight species were maintained during the year under report. Some of the species like *Cyamopsis psoralioides* (local and Texas), *Crotalaria juncea* (Chinese), and *Crotalaria alata* could not thrive due to heavy downpour during the month of September. Twelve species viz., *Aeschynomene americana*, *Crotalaria juncea*, *C. usaramoensis*, *C. striata*, *Phaseolus semierectus*, *Sesbania macrocarpa*, *S. sericea*, *S. speciosa*, *S. aculeata*, *Cassia leschenaultiana*, *C. tora* and *Indigo* sp. which appeared promissing were multiplied and seeds were supplied to various research workers for trials in different parts of the country and abroad.

Residual effect of green manure.—To study the residual effect of green manure after applying continuously for two and three years and also in alternate years, an experiment was initiated during the year under report. *Sesbania aculeata* was grown *in situ* and ploughed under at the rate of 5600 Kg green matter per hectare. T. 141, a medium duration variety was grown in the experiment. The residual effect of green manure will be studied from next year onward. The grain yields of rice are presented in Table XIII below :

TABLE XIII

Sl. No.	Treatments	Yield in Kg/Ha
1	No green manure (control)	2732
2	Alternate year green manuring	3122
3	Two years continuous green maunring	3122
4	Three years continuous green manuring	3085

The data presented in the table above indicate that all the green manure treatments have given higher yields over that of no-manure control. Since the residual effect has to be studied from next year, no detailed discussion on the results are intended.

IV. *Cultural Trials*

Crop sequence experiment :

To determine the possibility of growing different legumes and cash crops in sequence with main season rice crop this experiment was carried out with nine rotational treatments in four replications. Six different crops besides dalua or boro crop of rice were grown during the preceding winter season to determine their suitability for inclusion in sequence of cropping with rice and to study their effect on the succeeding rice crop. A short duration variety PTB. 10 was grown during the main season so that the field might be available for sowing winter crops in the month of November.

The results indicated that yields of rice crop following Berseem, wheat/green manuring, rice/green manuring, groundnut, gram and cotton were found to be statistically on the same level which showed the benefits of inclusion, of leguminous crops in sequence with rice in increasing the yield of the latter. Due to unavailability of water supply, the crops grown in the preceding rabi season particularly rice, groundnut, wheat and linseed did not establish well.

Herbicides for weed control in rice fields :

This experiment has been in progress for the last eight years to evaluate the comparative efficiency of various selective herbicides for control of weeds in rice fields. The treatments consisted of different formulations of herbicides, customary hand weeding and Japanese rotary weeder. This year one new trade product Dowpon (Sodium salt of Dalapon) replaced Agromore weedazol which was found ineffective. Herbicides were sprayed six weeks after planting @ 2 lb. acid equivalent per acre in 100 gallons of water. Within a few days of spraying the susceptible weeds mainly *Fimbristylis sp.*, *Cyperus* and other broad leaved ones developed cholrosis and ultimately succumbed to herbicidal action. The grain yields of crop obtained from various treatments are presented in the Table XIV below :

TABLE XIV

Efficiency of selective herbicide

Grain yield data in Kg/Ha

Variety T.141

Sl. No.	Treatments	Yield in Kg/Ha	% over control
1	Control	1763	100
2	Hand weeding	2055	117
3	Japanese weeder	2004	114
4	Phenoxylene-30	1878	107
5	Agroxone	1218	69
6	Chlorozone	1833	104
7	Fernoxone	1719	98
8	Shell, 2·4 D.	1656	94
9	Kathon M,	1935	110
10	Cornox	1687	96
11	Isocornox	1757	100
12	Extar 'A'	1738	99
13	Extar 'D'	1814	103
14	Dowpon	1472	84
15	Agromore T.C.A.	2169	123
16	Agromore weedone choloro-I.P.C.	1535	87

C.D. (0·05) to compare treatment means = 465.

From the above table it would be found that none of the treatments was significantly superior to the control, though spraying with Agromore T.C.A., Hand weeding and Japanese rotary hoe treatments gave 23, 17 and 14 per cent higher grain yields respectively over control.

Time of spraying herbicides for weed control in broadcast Crop.—This experiment was conducted with some modifications in the treatments to determine the suitable time of spraying of herbicide for control of weeds in broadcast crop of paddy. Phenoxylene-30 (M.C.P.A.) at 2 lb acid equivalent was sprayed at different intervals including a pre-emergence treatment where soil application was made just before the sowing. Variety PTB.10 (110 days) duration was grown in the experiment. The grain yield data are presented in Table XV below :

TABLE XV

Grain yield data of time of spraying herbicide for broadcast rice

Variety PTB.10.

Sl. No.	Treatments	Yield in Kg/Ha	Percentage over control
1	Control	231	100
2	Hand weeding 30 & 45 days after sowing	243	105
3	Pre-emergence application	482	209
4	Spraying 15 days after sowing	756	327
5	Spraying 30 days after sowing	421	182
6	Spraying 45 days after sowing	447	194
7	Spraying 15 & 30 days after sowing	316	137
8	Spraying 15 & 45 days after sowing	333	144
9	Spraying 30 & 45 days after sowing	414	179
10	Spraying 15, 30 & 45 days after sowing	404	175

Since the crop was submerged under water at the time of panicle emergence the grain yields in general were poor. However, the effects of various treatments are indicative. The control treatment gave the least yield of 231 Kg/Ha immediately followed by the handweeding treatment at 30 and 45 days after sowing with a grain yield of 243 Kg/Ha. The highest grain yield of 756 Kg/Ha was obtained from the treatment where Phenoxylene-30 was sprayed 15 days after sowing *i.e.* after the germination was complete. Rest of the treatments gave almost equal performances which were lower than that of the treatment where spraying was done 15 days after sowing. One interesting phenomenon was noticed that in the pre-emergence treatment the germination was very badly affected, still it recorded the second highest yield. This might be due to comparatively lesser number of weeds to compete with the crop. However, the differences in treatements were not statistically significant.

Cultural-cum-*chemical method of weed control :*

To determine the judicious combination of cultural-*cum*-chemical methods for efficient control of weeds, this experiment was repeated for the third year in succession. Phenoxylene-30 (M.C.P.A.) a selective herbicide which proved its superiority over others in previous years' trials, was sprayed @2 lb. acid equivalent per acre in 100 gallons of water. Variety T. 141 (145 days duration) was grown in the experiment. The average yields of grain are presented in Table XVI below :

TABLE XVI

Cultural-cum-*chemical methods of weed control*

Grain yield data in Kg/Ha

Sl. No.	Treatments	Yield in Kg/Ha	Percentage over control
1	Sprayed two weeks after planting	1680	65·8
2	Sprayed 6 weeks after planting .	2237	87·7
3	Sprayed 10 weeks after planting .	2089	81·9
4	Japanese weeder 2 weeks after planting	2613	102·4
5	Japanese weeder 6 weeks after planting	2017	79·1
6	Japanese weeder 10 weeks after planting	2771	108·6
7	Japanese weeder two weeks after +spraying six weeks after planting	1827	71.6
8	Japanese weeder 2 weeks after + spraying two weeks after planting	2237	87·7
9	Japanese weeder six weeks after + spraying 10 weeks after planting	2277	89·3
10	Spraying 2 weeks after + Japanese weeder six weeks after planting	2890	113·3
11	Spraying 2 weeks after + Japanese weeder 10 weeks after planting	2880	112·9
12	Spraying six weeks after + Japanese weeder 10 weeks after planting	2548	99·9
13	Japanese weeder 2 & 6 weeks after + spraying 10 weeks after planting	1995	78·2
14	Japanese weeder 2, 6 and 10 weeks after + spraying 10 weeks after planting	1974	77·4
15	Japanese weeder 2, 6 and 10 weeks after planting	2356	92·4
16	Hand weeding 6 weeks after + spraying 10 weeks after planting	2256	88·4
17	Hand weeding six weeks after planting	2611	102·4
18	Control	2551	100·0

C.D. (0·05) to compare treatment means=152.

It might be seen from the above table that the treatments in which Japanese weeder was run ten weeks after the date of transplanting alone and in conjunction with a spray of Phenoxylene-30 two weeks after transplanting gave significantly higher yields over control. The only other treatment which was also significantly superior to control was the one in which spraying was done two weeks after followed by Japanese weeder six weeks after planting. Rest of the treatments were either at par with or inferior to the control.

Double cropping experiment :

To find out the possibility of growing two crops of rice within the Kharif season (June to December) taking advantage of the monsoon rain, six early duration varieties *viz.*, N. 136, CH. 10. DCA. 14, PTB. 10, CH. 45 and CH. 47 (maturing within 100 days) were planted in the fourth week of June and harvested in the third week of September except the variety CH. 47 which was harvested pre-mature to facilitate the planting of the second crop. The second crop of rice consisting of five varieties *viz.*, T. 141, T. 1242, J. 192, BAM. 9 and T. 90 were planted in the fourth week of September and harvested by the begining of January. The yields of grain obtained from both the crops (first and second crop of rice) are presented in Table XVII below :

TABLE XVII

Double cropping experiment

Yield of grain in Kg/Ha

First crop		Second crop	
Varieties	Yield in Kg/Ha	Varieties	Yield in Kg/Ha
CH.45	3084	T.1242	1261
PTB.10	3033	J-192	1255
DCA-14	2551	T.141	1127
N-136	2521	T.90	1007
CH.10	2375	BAM.9	325

It might be seen from the above table that among the early duration varieties grown as first crop CH. 45 and PTB. 10 yielded 3084 and 3033 Kg/Ha respectively, while the rest of the varieties recorded grain yields of 2500 Kg/Ha or less. The yields of second crop varieties were rather poor partly due to very late planting which resulted in a short vegetative phase of the crop before flowering and partly due to the pests and disease incidence.

Spacing × No. of seedlings per hill :

To find out the optimum spacing and optimum number of seedlings per hill a field experiment was initiated during the year 1959 and was repeated for the third year in succession. The experiment was conducted in a split plot layout with spacings (15 cm. × 7·5 cm., 15 cm. × 15 cm., 15 cm. × 22·5 cm. and 15 cm. × 30 cm.) as main plot treatment and number of seedlings (2, 5 and 8 per hill) as sub-plot treatments. The variety T. 141 (145 days duration) was grown in this experiment. The average grain yield data are presented in the Table XVIII :

TABLE XVIII

Spacing × No. of seedlings per hill experiment

Yield of grain in Kg/Ha

No. of seedlings per hill / Spacings	2 per hill	5 per hill	8 per hill	Means
15 cm. × 7·5 cm.	2557	2417	2261	2412
15 cm. × 15 cm.	2079	2096	2482	2219
15 cm. × 22·5 cm.	1927	2196	2245	2123
15 cm. × 30 cm.	2112	2154	2411	2226
Mean	2169	2216	2350	

S.E. for spacing means	= ± 116
S.E. for number of seedlings means	= ± 89
S.E. for number of seedling means within spacing	= ± 176
S.E. for spacing means within number of seedlings	= ± 185

The results indicate that there was no significant difference between the different spacings and different number of seedlings per hill. The interactions between spacings and number of seedlings per hill were not significant.

V. *Cultural-cum-Manurial Trials*

Experiment with bacterial manure :

To assess the manurial value of bacterial culture, Azotobacterin received from Moscow through the Head of the Division of Soil Science and Agricultural Chemistry, Indian Agricultural Research Institute, New Delhi, two field experiments—one under upland and the other under low-land conditions were conducted during the year under report. The Azotobacterin was inoculated alone and in combinations with N, P and P, K. Another new experiment was initiated during this year to study the comparative efficiency of Russian and local strains of Azotobacterin. Due to unprecedented inundation during the first week of September all the three experiments on Azotobacterin were completely damaged.

Cultural and nutritional requirement of different rice varieties :

To study the differential response of rice varieties to different dates of planting, spacings and levels of nitrogen alone and in combinations an experiment was initiated during the year with four factors *viz.*, three dates of planting (16th June, 16th July and 16th August), three levels of nitrogen (0, 33 and 66 Kg N/Ha), three spacings (15 cm. × 7·5 cm., 15 cm. × 15 c.m and 15 cm. × 22·5 cm.) and two varieties (T. 141 of 145 days duration and T. 90 of 160 days duration). The experiment was conducted in a strip-*cum*-split plot design with three replications. The grain yield data are presented in Tables XIX (a), (b) and (c).

TABLE XIX (*a*)

Yield of Grain in Kg/Ha

Dates of planting	Levels of N in Kg/Ha			Mean
	NO	N33	N66	
16th June	3024	3332	2542	2966
16th July	2757	3321	2632	2903
16th August	2800	3311	3520	3210
Mean	2860	3321	2898	

S.Ed. for comparing date of planting	= ± 184·285
S.Ed. for comparing level of nitrogen	= ± 112·124*
C.D. (0·05) per Hectare of nitrogen	311
S.Ed. for comparing date of planting within same level of N	= ± 191·662**
C.D. (0·05) per Hectare	525
S.Ed. for comparing nitrogen within same date of planting	= ± 124·055**
C.D. (0·05) per Hectare	334

TABLE XIX (*b*)

Yield of grain in Kg/Ha

Dates of planting	Spacing in cms.			Mean
	(15×7·5)	(15×15)	(15×22·5)	
16th June	2368	3069	3191	2966
16th July	2677	3024	3008	2903
16th August	3172	3520	2939	3210
Mean	2829	3204	3046	

S.Ed. for comparing spacing	= ± 54·779**
C.D. (0·05) per hectare	109
S.Ed. for comparing date within same spacing	= ± 200·001**
C.D. (0·05) per hectare	531
S.Ed. for comparing spacing within same date	= ± 95·126**
C.D. (0·05) per hectare	189

TABLE XIX (*c*)

Yield of grain in Kg/Ha

Dates of planting	Variety		Mean
	T. 141	T. 90	
16th June	3688	2243	2966
16th July	3384	2422	2903
16th August	3242	3178	3210
Mean	3438	2614	

S.Ed. for comparing variety	= ± 44·452**
C.D. (0·05) per hectare	89
S.Ed. for comparing variety within date	= ± 77·486**
C.D. (0·05) per hectare	154

From the above tables it would be seen that out of four factors studied in the experiment three factors *viz.*, level of nitrogen, variety and spacing individually showed significant difference among themselves, whereas the yield differences due to various dates of planting were not significant. The interactions between nitrogen × dates of planting, spacing × dates of planting, varieties × dates of planting and spacing × varieties × dates of planting were statistically significant.

Among the levels of nitrogen, the highest grain yield of 3321 Kg/Ha was obtained with 33 Kg N/Ha which was significantly superior to both no-manure control and 66 Kg N/Ha. The spacing of 15 cm. × 15 cm. (6″ × 6″ gave the highest yield of 3214 Kg/Ha which was significantly superior to the spacings of 15 cm. × 7·5 cm. (6″ × 3″) and 15 cm. × 22·5 cm. (6″ × 9″), the last being significantly better than that of the spacing of 15 cm. × 7·5 cm. Among the two varieties, T. 141 was found to be significantly superior to T. 90 by recording an extra grain yield of 824 Kg/Ha.

The differential response of both the varieties to increasing levels of nitrogen was not significant. But it is interesting to note that the manurial and cultural requirements of the varieties differ with the dates of planting as evidenced by the significant interactions of level of nitrogen, spacing and varieties with different date of planting. It might be seen from the tables presented above that while for 16th June and 16th July plantings, 33 Kg N/Ha is the optimum dose for obtaining the highest yield, for 16th August planting 66 Kg N/Ha is probably the required dose. So far as the effect of dates of planting on the spacing is concerned, the earliest planting on 16th June requires a spacing of 15 × 22·5 cm. which yielded 3191 Kg/Ha. This is explainable from the point of view of the fact that with the plantings as early as in the middle of June, there is ample time for manifestation of the vegetative phase preceding the reproductive phase which enables in increased yields over the other two narrower spacings. For the 16th July and 16th August plantings the spacing of 15 cm. × 15cm. is by far the best. Wider spacing in

late or very late planting significantly decreased the yield. There is significant differential response of the varieties according to different dates of planting. While the variety T. 141 decreases in yield with every later planting from 3688 to 3242 Kg/Ha, the variety T. 90 increases in yield with every late planting from 2243 to 3178 Kg/Ha. This finding in particular shows the potentialities of some varieties like T. 90 which can stand not only late planting but can also improve the yield. This is of practical value in the areas affected with flood which requires late planting forced by the environmental circumstances.

VI. *Miscellaneous Experiments*

Mixed cropping Experiment :

To find out the possibility of growing three varieties of rice together belonging to three different durations, seeds of CH. 2 (82 days), T. 1145 (140 days) and Co. 25 (180 days) were mixed @ 20, 37 and 38 Kg/Ha respectively and were sown broadcast in the first week of May. Single superphosphate 44 Kg P_2O_5/Ha was applied to the field just before sowing. The field had irrigation facilities. To study the effect of beushening and pruning four unreplicated treatments *viz.*, (i) Beushened unpruned, (ii) Beushened pruned, (iii) unbeushened unpruned, and (iv) unbeushened pruned were super-imposed over the general experiment. 44 Kg N/Ha was applied in the form of Ammonium Sulphate in two splits. The varieties CH. 2, T. 1145, and Co. 25 were harvested in 3rd week of September, 2nd week of November and 3rd week of January respectively, date of sowing being first week of May for all the varieties. The treatmentwise yield data are presented in Table XX below :

TABLE XX

Yield of grain in Kg/Ha

Treatments	Names of varieties			
	CH.2	T.1145	Co.25	Total
Beushened unpruned . . .	29	1238	1775	3042
Beushened pruned	43	800	1775	2618
Unbeushened pruned . . .	37	774	1290	2101
Unbeushened unpruned . . .	39	864	1006	1909

From the data presented above, it might be seen that maximum grain yield of 3042 Kg/Ha has been obtained from the treatment where the crop was beushened. When the crop was not beushened, pruning was necessary as is evidenced by higher yield of 192 Kg/Ha of pruned treatment over unbeushened unpruned treatment. Among the varieties Co. 25 (180 days duration) gave the highest yield followed by T. 1145 and CH. 2. Since the crop was submerged under water just before the harvest of CH. 2, the yield of the said variety had been abnormally depressed.

Botany

I. *Maintenance and Study of Genetic Stocks*

The genetic stocks collection now stands at 3452. During the year seed samples of 59 varieties were received from 15 foreign countries. In addition, 19 types were obtained from 4 states in India. In the same period, in response to requests from different countries and from different states in India a total number of 696 varieties (36 to 9 foreign countries and the rest to different States in India) was despatched.

The Director, Central Rice Research Institute, continued to be in overall supervision of the F. A. O. scheme for the maintenence of *japonica*, *indicas*, *bulus* and floating types at the different centres in the world.

Observation on the occurrence of pigmentation (anthocyanin and non-anthocyanin) in the different plant parts, and on the various morphological characters were taken on the varieties received during the year.

Based on the general performance of the varieties in the Genetic Stocks collection and on the data already available on these, 12 varieties were slected for preliminary yield trials.

II. *Agro-genetical studies*

As a result of continuous rain during the beginning of September almost all the experimental plots were under water for 5 to 6 days. The standing crop in the different stages of growth was affected to a considerable extent and the final yield of the different material therefore was comparatively low in many experiments. Such of the experiments as were involving different evels of fertility gave inconsistent and vitiated results.

Breeding for high yield and response to heavy soil fertility between japonica *and* indica *rices :*

Bulk trial.—The trials in the different generations were carried out under two levels of fertility *i.e.* normal and high. The normal fertility plots received 40 lb N in the form of Ammonium Sulphate while a dose of 80 lb N was given to plots under high fertility level. All the plots received a basal dressing of 36 lb P_2O_5 applied in the form of superphosphate. The number of cultures tried in the different generations, the level of fertility, the number of cross combinations and the number of standards are furnished in Table XXI.

Table XXI

Number of cultures tested, number of cross combinations involved, standards and the level of fertility

Sl. No.	Generation	No. of cultures tested	No. of cross combinations	Standards	Level of fertility
1	F_8	10	5	GEB 24 T.1145 T. 812 Bam 6 Bam 9	Normal

Number of cultures, tested, number of cross combinations involved, standards and the level of fertility

Sl. No.	Generation	No. of cultures tested	No. of cross combinations	Standards	Level of fertility
2	F_9	5	3	T. 141 T. 1145 [Dharial]	Normal
3	. . .	3	1	T. 141 GEB. 24 Dharial	High
4	F_{10}	15	4	T. 141 T. 1145 GEB. 24	High
5	F_{11}	8	6	T. 812 Bam 9 Adt. 12 GEB. 24	Normal and high
6		11	7	T. 812 T. 1145 Adt. 12 GEB. 24 Bam 6 Bam 9	Normal and high
7		17	8	Bam 9 T. 141	Normal and high

Randomised block design was adopted in all cases with the number of replications varying in the different experiments.

Results.—In the first trial at F_8 generation, no culture was significantly superior to T. 1145, T. 812 or Bam 6 which yielded 1616 kg, 2029 kg and 2399 kg, per hectare respectively; however, when compared with Bam 9 and GEB.24, 3 cultures (2 from Zuiho × C.401 and 1 from Norin 20 × Quezon) yielding respectively 1275 kg, 1598 kg and 1618 kg per hectare were significantly superior. It may, however, be pointed out that the yields of Bam 9 and GEB.24 were unusually low being 717 and 761 kg per hectare respectively.

Among the 5 cultures tried under normal fertility, one culture (2053-2-61-4) from Norin 8 × Dharial combination was significantly superior to Dharial which gave an yield of only 613 kg. per hectare. The yield of the superior culture was 1327 kg. per hectare. No culture was significantly superior to T.141 which gave an yield of 1453 kg. per hectare. Two cultures from T.1145 combination gave increased yield over T.1145 but the yields were not significant.

In the third tiral, one culture (2053-2-59-41) from Norin 18×Dharial combination gave significantly increased yield (1671 kg/ha) over Dharial (753 kg/ha).

Three cultures in the fourth trial yielding respectively 1627, 1663 and 1759 kg/ha were on par with T.141 which gave an yield of 1575 kg per hectare. Among these, only one culture was significantly superior to the other two standards T.1145 and GEB.24. Two cultures gave increased yield over T.1145 which was significant. T.1145 and GEB.24 gave 1001 and 1092 kg. per hectare respectively.

Three trials were conducted in F_{11} generation. In the first trial, no culture was significantly superior to T.812 under both levels of fertility. Five cultures gave a markedly increased yield at high fertility level than at low fertility level. Under normal fertility level, 1 culture from Adt 12 combination (1659 kg/ha), 2 from GEB.24 combination (2133, 2759 kg/ha) and 1 from Bam 9 combination (1953 kg/ha) were significantly superior in yield to their respective *indica* parent. Two cultures from GEB.24 combination (1920, 2271 kg/ha), 1 from Adt 12 combination (1555 kg/ha) and 1 from Bam 9 combination (1788 kg/ha) gave significantly increased yield over their respective *indica* parent. The maximum yield of 2271 kg/ha was obtained in a culture from the combination GEB.24×Taichu 65 under low fertility level ; at high fertility level 1 culture from Norin 6×GEB.24 combination gave an yield of 2759 kg. per hectare. One culture each from (Norin 6×GEB. 24) and (GEB. 24×Taichu 65) combinations and 1 from (Norin 17×Adt. 12) combination gave significantly superior yield over their respective *indica* parent at both levels of fertility.

In the next trial (6) 4 cultures (*i.e.* one each from T.1145 × Norin 36, Norin 17× Adt.12, Bam 6× Norin 36, and T.812× Asahi combination) gave increased yield at high fertility level. Their yields ranged from 1408 to 2305 kg per hectare. No culture was significantly superior to T.812 (2168 kg/ha) under high fertility level while at normal fertility level one culture from Norin 6× GEB.24 combination (2719 kg/ha) gave significantly superior yield over this standard. Bam 6 recorded the highest yield (2399 kg/ha) under normal fertility level. One culture from Adt 12 combination) 1 from T.1145 combination and 1 from GEB.24 combination yielding respectively 1866, 2305 and 2318 kg/ha were significantly superior in yield to their *indica* parent under high fertility level, while at normal fertility level 1 culture from Bam 9 combination yileding 1710 kg/ha and 2 cultures from GEB.24 combination recording 1306 and 2719 kg/ha respectively were significantly superior to their *indica* parent. The remaining cultures were not significantly superior to their respective *indica* parent.

Of the 17 cultures included in the last trial, 15 gave increased yield at high fertility level. The yield of Bam 9 was unusually low and no comparison is made with this parent. T.141 gave an yield of 1362 kg/ha under normal fertility level and 1802 kg/ha under high fertility level. While no culture was significantly superior to T.141 under normal fertility level, one culture from T.1145×Taihoku 6 combination yielding 2451 kg/ha was significantly superior to this standard under high fertility level.

Progeny row trials.—Six progeny row trials belonging to 5 generations were conducted under different levels of fertility. The number of cultures included in the different trials, and the level of fertility are given in Table XXII.

TABLE XXII

Number of cultures tested, number of cross combinations, generation, and level of fertility.

Generation	Number of cultures tested	Number of cross combinations	Level of fertility
F_6	38	2	80 lb N+36 lb P_2O_5
F_7	12		0N+0. P_2O_5
	12		20N+18 P_2O_5
	12		40N+36P_2O_5
	12		80N+36.P_2O_5
F_8	41	9	80 lb N+36 lb P_2O_5
F_9	30	5	80 lb N+36 lb P_2O_5
	29		40 N+36 P_2O_5
	29		80 N+36 P_2O_5
F_{10}	27	6	80 N+36 P_2O_5

In all cases randomized block design was followed. The number of replications varied in the different experiments.

The first trial consisting of 38 families was carried out under high fertility level and the object is to obtain early, high yielding cultures which respond to the application of heavy doses of manures. Of these 38 families, 20 have been obtained from Fukoku × Bam 9 combination and the rest are from Zuiho × T.141 combination. Nine cultures in Fukoku × Bam 9 combination flowered within 80 to 110 days from the date of sowing while in the second combination 5 cultures flowered after 95—110 days. The yield of the families is in general low. Three cultures from the first combination yielding respectivly 1253, 1380 and 2785 kg/ha were also early in maturity. Two cultures from the latter combination gave 1960 and 2048 kg/ha respectively. A total number of 400 single plants has been selected for further laboratary studies.

The trial in the F_7 *generation* was badly affected by submergence of water. There was considerable variation even at this stage. In the absence of any reliable criterion the different families have been bulked.

In the trial at F_8 generation, the yield of the different families and the standards was comparatively low. With the exception of 2 families from the combination involving C.401, the yield of the different cultures was not significantly superior to their respective *indica* parent. These cultures yielded 1225 and 1640 kg/ha. The variety Leaungyei gave the highest yield (2282 kg/ha) among the standards. Only one culture from the combination Zuiho × Kheo Khao gave significantly superior yield to this standard ; two cultures only gave yield exceeding 2000 kg/ha.

In the next trial at F_9 generation, the yield of 10 cultures from two combinations *viz.*, Norin 20 × T.1145 and Norin 18 × Patnai 23 was significantly superior to their respective *indica* parent. Of these, 9 are from the combination (Norin 20 × T. 1145) and their yield ranged from 2963 to 3758 kg. per hectare. The culture from the second combination recorded an yield of 2926 kg/ha. Eight cultures from (Norin 20 × T.1145) combination yielded more than T. 1145, their yield ranging from 2216 to 2748 kg/ha. Three cultures from Patnai 23 combination gave increased yield over this parent, their range in yield being from 2264 to 2761 kg/ha.

With the exception of one culture from Norin 8 × Dharial combination under high fertility level, no culture was significantly superior in yield to T.141 at both levels of fertility. T.141 recorded an yield of 1542 kg/ha under high fertility level and 2762 kg. under normal fertility level. In the normal fertility level, 18 cultures yielding from 2130 to 3113 kg/ha were significantly superior to GEB.24 (1445 kg/ha) and 10 cultures (yielding 2490 to 3113 kg/ha) were significantly superior to T.1145 (1800 kg/ha). Under high fertility conditions, 14 cultures (yielding 1560-2396 kg/ha) gave significantly increased yield over T.1145 (1016 kg/ha) and 20 cultures (yielding 1464-2396 kg/ha) gave increased yield over GEB.24 (932 kg/ha.) which was significant. In the last progeny row trial, one culture from Co.25 × Rikuu 132 combination gave significantly increased yield (3525 kg) over T.141 (2619 kg). The yield of 8 cultures was superior to T.141 but not significant. The yield of all 5 cultures from GEB.24 combination ranging from 2310 to 3005 was significantly superior to GEB.24 (1572 kg.) Thirteen cultures with a range in their yield from 2409 to 3525 kg/ha were significantly superior to Co.25 (1701 kg).

Preliminary yield trial of introduction :

Differential response of japonica *and Taiwan varieties to heavy doses of fertilizer application.*—This experiment was conducted to ascertain the nature of response of varieties to the application of heavy doses of nitrogenous fertilizers and the trend in their response. Seventy two *japonica* types from 6 countries and 15 varieties from Taiwan were included in the trial and up to 90 kg/ha of nitrogen was applied. The material were grown in two replications and a randomized block design was adopted. The treatments included O N. 45 kg.(N) and 90 kg.(N) per hectare. The fertilizer was applied in two split doses one at the time of planting and the second 25 days after planting. The plots received a basal dressing of 25 kg $P_2 O_5$ per hectare.

Fifty five *japonica* varieties and 11 Taiwan types gave progressively increased yield with increased dosages. There is however a great degree of variation among these types, in their nature of response. Among the 55 *japonica* varieties 35 types *i.e.* 17 from Japan, 8 from Italy, 5 from Russia, 2 from Egypt, 2 from Portugal and 1 from Argentina appear promising. In addition, the performance of 11 Taiwan types is also good and these appear very promising. A linear trend (positive response) was observed in all varieties except in two *indica* types for characters such as plant height, number of ear-bearing tillers, panicle length and grain yield.

Breeding for high yield and early maturity :

Six strains *viz.*, CR.1 to CR.6 evolved at this Institute were grown for seed multiplication. These are early in maturity and are high yielding. Seed samples of these varieties were also sent to different *japonica* × *indica* scheme units in the different States to obtain information on their adaptibility and cosmopolitan nature.

Breeding for high yield combined with quality :

As in previous years work to evolve high yielding varieties with good quality rice was continued. Ninety six cultures belonging to six intra-*indica* combination were tried in three generations as shown below :

Generation	No. of cultures tried	Cross combination
F_7	24	4
F_8	35	1
F_9	37	2

Most of the cultures in the F_7 generation trial are fine grained and lat in maturity. These cultures were tried against two standards *viz.*, T.141 and T.90 under normal fertility level *i.e.* 40 lb. N 36 lb P_2O_5. No culture was significantly superior in yield to either standard; however, 3 cultures gave increased yield over T. 141 (2423 kg/ha) and 4 cultures recorded more yield than T.90 (2292 kg./ha). Of the 3 cultures which gave increased yield over both standards one is from the combination T.2165 × Sathika, the second is derived from a cross between T.2165 × N136 and the third is from the cross combination T.90 × Pulut Nangka. The culture from the first combination is fine grained while others are medium grained.

In the progeny row trial at F_8 generation, 35 cultures were tried and these have been derived from the combination N.136 × Ptb 10. The cultures were badly affected as a result of continuous submersion under water and the yield of the cultures was low. Seeds of 11 cultures have been separately bulked for carrying out bulk trial during next year. The yield of the cultures ranged from 1006 to 1586 kg/ha.

Of the 37 cultures included in the F_9 generation trial, 30 are from N.136 × Ptb 10 combination, while the remaining cultures are from Ptb.10 × Ch.45 combination. The cultures from the first combination are medium grained and belong to medium maturity group. The cultures from the latter combination are long and coarse grained. Three cultures from N.136 × Ptb.10 combination are significantly superior in yield to both standards T.141 and T. 812 which gave 2804 and 2557 kg/ha. respectively. Eight cultures from N.136 × Ptg.10 combination yielding from 3333 to 3888 kg/ha were significantly superior to T. 812. Twenty two-cultures with a range in yield from 2865 to 3430 kg/ha were superior to the high yielding standard T. 141 but their differences were not significant. All these cultures have been derived from N.136 × Ptb.10 combination. The yield of the standards, details of the significantly superior cultures and their yield are given in Table XXIII.

TABLE XXIII

Culture number, yield of cultures and their cross combination

Sl. No.	Cross combination	Culture number	Yield (in kg./ ha)
1	N.136×Ptb.10	1	3,888
2	,,	3	3,428
3	,,	4	3,865
4	,,	8	3,407
5	,,	16	3,670
6	,,	20	3,430
7	,,	22	3,362
8	,,	25	3,333
		T.141	2,804
		T.812	2,552

C.D. 777 kg/ha.

Improving yield of basumati rices :

Purification work in the bulk samples of three basumati types (obtained from Punjab, Kulu valley and Dehra Dun) was continued and single plan selections have been made in the three samples.

Five cultures obtained as a result of secondary selection in the basumati rices have more or less attained homozygosity. Seeds of the cultures have been multiplied for trials. These cultures belong to medium maturity group.

Breeding for disease resistance :

Blast.—Work on breeding high yielding, early and blast resistant strains was continued in collaboration with the Mycologist.

Sixty-four cultures were included in five trials conducted at different generations. The details of the cultures and their range in yield and ear-bearing tillers are shown in Table XXIV.

TABLE XXIV

Details of the cultures in the different generation

Generation	No. of cultures	Single plant yield (in gms.)		Number of ear-bearing tillers	
		Min.	Max.	Min.	Max.
F_7	20	19·0	54·0	11	27
F_8	10	22·0	51·0	10	25
F_9	14	30·0	61·0	12	26
F_{10}	13	36·0	64·0	9	22
F_{11}	8	38·0	60·0	12	18

The seedbeds and the experimental plot were heavily manured. The cultures were artificially inoculated at the seedling stage and observations were recorded on the resistance capacity of the cultures. In the field, the different cultures were flanked by a single row of susceptible variety, Co.13 to provide sufficient natural inoculum for infection. The scoring was recorded at 3 different stages *e.g.* (i) before transplanting, (ii) at tillering phase, and (iii) at harvest time.

Seventy single plant selections have been finally retained.

Bulk trial.—Eight homozygous cultures were tried in a bulk trial against three standards *viz.*, T.141, Co.13 and Co.25. The general stand of the cultures was very unsatisfactory as a result of submergence under water for 5 days. The analysis was therefore not carried out. Seeds of the cultures have been separately bulked.

Helminthosporium and blast.—Twelve cultures belonging to Co.25 × Bam 10 combination were included in this progeny row trial. The lines of the cultures were alternated with a row of Benibhog to serve as a source of infection. Based on the resistance capacity of the plants to blast as well as helminthosporium, 9 single plant selections have been retained.

Breeding for profuse tillering and high yield :

This project is in its 5th year and two progeny row trials were conducted in two generation *viz.*, F_5 and F_7. In the 5th generation trial, 18 cultures from the combination CRRI dwarf × Cp.12 were tested against T. 141. The standard T.141 gave the maximum yield of 3890 kg/ha and no culture was therefore significantly superior to this standard. The yield of the cultures was low and as a result only single plant selections were made. Twenty-seven selections have been finally retained.

In the trial at F_7 generation, all the 44 cultures yielded lower than the standard T.141 (3890 kg/ha). Ten cultures gave yields over 2000 kg/ha and one culture recorded a yield of 3242 kg/ha. Forty-nine single plant selections have been retained in this trial.

Breeding for high yield and low photo-sensitivity :

This experiment conducted with 41 cultures was badly affected and no analysis was carried out. Seeds in sufficient quantity could be secured only in 6 cultures and these cultures have been sown in the second crop season. In addition, F_2 generation of six crosses has been raised to select low sensitive or insensitive cultures.

Practical utilisation of heterosis :

It is known that variation exists to a considerable degree in the expression of heterosis among the F_1 hybrids for several characters. With a view to utilise the heterosis in the best possible way, the F_1 plants belonging to several cross-combinations are being carefully studied for different characters. Further, the F_1 plants are all being maintained by means of vegetative propagation.

In this connection, work on vegetative propagation was intensified. During this year it was observed that the vegetatively propagated rice crop was able to withstand submergence under water for 5-6 days to a greater extent than the crop raised through seedlings.

Another salient observation was also recorded. It was observed this year that after the water had drained away from the fields, almost all the experimental material became highly susceptible to a physiological disease which resulted in the bronzing of leaves. It is significant to note that prolonged submergence did not result in the bronzing of the leaves in the stubble crop.

The crop raised through tiller propagation method was uniform for heading behaviour. Preliminary studies also indicate that in some instances the yield of the stubble crop was more than the yield of crop raised in the usual manner through seedlings.

Breeding technique :

This project is in its third year. A total number of 154 single plant selections was tested under two levels of fertility *viz.*, 40 lb N and 80 lb N. At the high fertility level, there were 77 cultures from Fukoku × T.141 combination and 46 from Zuiho × S.1092 combination; at the normal level of fertility (40 lb. N), 15 cultures from the first combination and 16 from the second combination were studied. Along with the cultures, material belonging to the original bulk and to modified bulk of these combinations and the parents were grown. The experiment was conducted in a randomized block design with 2 replications.

The general performance of the cultures was good under high fertility level. This was well marked in the cultures belonging to Fukoku × T.141 combination. The cultures have not attained uniformity in both combinations. Forty-nine cultures from Fukoku × T.141 combination gave increased yield over T.141 and of these 8 cultures were outstanding in their general performance. Based on height, ear-bearing tillers, nature of panicle, general performance of the culture as a whole and habit of the plants, 381 field selections were made. The number of promising single plant selections and their yield are given in Table XXV.

TABLE XXV

Number of single plant selection with 50 gms. and above

Level of fertility	Combination	Yield in gms. of single plant selection						
		50	51-60	61-70	71-80	81-90	91-100	Total
High (80 lb.N)	Fukoku × T.141	17	49	24	7	2	1	100
	Zuiho × S.1092	2	28	6	5	3	1	45
Normal (40 lb.N)	Fukoku × T.141	..	2	..	1	..	..	3
	Zuiho × S.1092	..	..	..	..	..	..	..

In the combination Zuiho × S.1092, 24 cultures gave increased yield over S.1092 and among these the performance of 3 cultures was very good. Eleven other cultures also showed promise. Forty-five single plant selections have been retained as shown in Table XXV.

The cultures from Fukoku × T.141 combination are very promising and there exists much scope for further exploitation.

The performance of the cultures under normal fertility level was unsatisfactory in both combinations. Seven cultures gave increased yield over T.141 and of these 4 appear promising. Twenty single plant selections were retained. In the combination Zuiho × S.1092, a total number of 25 selections was retained.

In the modified bulk plots, single plant selections were made as usual in the different fertility levels. The stand was not good in general.

From the data collected so far in this experiment it may be concluded that (i) the performance of cultures is good at the high fertility level (ii) potentiality for improvement is high in the material grown under high fertility level. (iii) T. 141 is a good combining parent (iv) natural selection does not always select the best and high yielding plants (v) pedigree method is reliable and efficient.

III. *Genetical studies*

New crosses made—For the study on the inheritance of hairiness, clustering habit, dwarf, anthocyanin coloration in the leaf blade and other plant parts and liguleless condition a series of crosses was made. In addition, several *glaberrima* types were crossed amongst themselves and with representative *indica*, *japonica* and Indonesian types to study inter-relationship of members in the two cultivated species. Attempts were also made to obtain crossed seeds in several interspecific crosses.

Additional evidence for the parallel evolution of the two cultivated species *viz.*, O. *glaberrima* and O. *Sativa* were obtained. The F_1 plant) obtained in a cross between Ac.2663 (O. *sativa*) and Warivayo (O. *glaberrimas* were sterile with long acuminate ligule. Presence of awns, branched habit of panicle and perennating habit showed dominance. In the lax nature and the panicles and in the shattering habit of the spikelets, the plants were a "reversion" to the wild ancestral type.

Studies in F_2 generation :

Super clustering in rice.—The occurrence of super clustering in a rice variety had been reported earlier. This super clustering is due to close arrangement of the clusters in bunches. As had already been reported the bunching was not prominent in the F_1 the terminals of branches of the panicles having only two spikelets. In the F_2 generation of a cross between a normal clustered variety Ac.1224 and the super clustered type Ac.3776 in addition to the parental types normal plants without clustering was obtained. Further, among the plants with the bunched habit, the number of spikelets in the bunches showed a variation. Evidence from the F_2 data indicate that the genes governing super-clustering are independent of those governing normal clustering in rice. Modifiers influence super clustering in addition to major gene pair. The behaviour of the plants with different types of clustering would be studied next year.

In the cross studied above, straw hull colour showed dominance over gold hull and normal glume was dominant to long glume. A ratio 3:1 was obtained in both studies.

Hairiness in rice.—In the F_2 generation of a cross between a glabrous type GS 215 and a hairy variety GS 513 a ratio of 3 hairy; 1 glabrous hull was obtained indicating that a single gene pair governs the expression of this character. This gene has pleiotropic effect on the expression of hairs in the leaf blade also.

The joint segregation was studied between absence or presence of hair and apiculus coloration. Evidence showed absence of any association between genes governing these characters.

Velvetty nature of lemma and palea.—The variety Ac.1778 has numerous hairs distributed on the lemma and palea thus giving a velvetty appearance. In the F_2 generation of a cross between Ac.1778 and a glabrous type GS 215 in addition to smooth hulled and velvetty hulled grains a few plants had grains with normal type of hairiness indicating that the genes governing velvetty nature of lemma and palea are independent of the genes governing normal hairiness in this part. Velvettiness is also influenced by a system of modifiers.

Notched kernel.—In the F_2 generation of a cross between Ac.1107 a variety with notched kernel and a liguleless type Ac.3778 a ratio 13:3 of absence to presence (notching) was obtained showing inhibitory gene action. It has been concluded that notching is governed by a single pair of genes and the action of this gene is inhibited by the presence of another inhibitor gene.

Auricle ligule and junctura.—In the cross studied for the inheritance of notched kernel, the F_2 segregated in a ratio 3:1 of presence to absence indicating that the presence of these parts is governed by a single pair of genes. A similar ratio was also obtained in another cross Ac. 3778 and Ac.37.

Anthocyanin pigmentation.—The following ratios were obtained for the occurrence of pigmentation in the apiculus and glume in a cross between Ac.3778 and a normal type Ac.37 :—

Presence *Vs* absence of coloration in apiculus—9:7

Presence *Vs* absence of coloration in glume—27:37

Studies on joint segregation showed that the two genes influencing coloration in the apiculus are also essential for coloration in the glume; however, the occurrence of pigmentation in the glume is further dependent on another pair of genes. This third pair of genes is probably a localization gene.

Studies on protein content and aleurone layer thickness :

This investigation was initiated to provide information on the variation in the protein content of rice varieties. The aleurone layer thickness was also studied in these types. The present studies were carried out with representative types from *japonica*, *indica* and *javonica* groups and so far 450 types were studied.

In the present investigation the protein content in the rice kernels varied from 6·1% to 10·1% and the aleurone layer thickness showed a range from 11·2 μ to 75·0 μ.

There was in general a positive correlation between the aleurone layer thickness and percentage of protein content in the rice kernels. In Table XXVI is given the mean aleurone layer thickness and protein content of types included in different groups.

TABLE XXVI

Thickness of aleurone layer and protein content in rice varieties

Variety	Aleurone layer thickness (x)		Protein content % (y)		Correlation coefficient between x and y
	Mean	S.D.	Mean	S.D.	
Indica					
White . .	34·07	10·41	8·01	1·2	0·6390 ± 0·024
Coloured . .	47·14	5·78	9·63	0·6	0·5210 ± 0·022
Japonica . .	42·47	12·70	9·34	1·9	0·9742 ± 0·052
Javanica . .	35·00	13·05	8·41	1·6	0·9002 ± 0·085

Studies in hulling percentage.—Preliminary studies were initiated to ascertain the extent of variability existing among the varieties in the collection and to screen out varieties with better hulling percentage. The investigation carried out by the use of a sheller has brought out valuable information. The findings are summarised below :—

(i) percentage recovery in the form of total rice varied from 70·4 to 79·2; head rice recovery showed a variation from 23·8 to 74·5.

(ii) percentage of head rice recovery is independent of total recovery percentage.

(iii) shape and size of the grains have considerable influence on the hulling percentage.

(iv) percentage of brokens is influenced by the nature and texture of endosperm.

(v) the presence of abdominal white does not appear to possess considerable influence on the percentage of broken grains.

(vi) the nature of adherance of the husk to the kernel is variable and appears to be a varietal characteristic.

(vii) small grains (either fine or bold) have in general a higher recovery percentage than medium and long grains.

(viii) Varieties *Emata Amagyi* and *Gokong* from Burma, *Changsan* from Manipur and JBS.1162 from Jeypore tract of Orissa have a high hulling percentage. The highest recovery percentage (79·2) was obtained in the variety changsan, a glabrous type.

IV. *Study of lodging and breeding for non-lodging habit*

Two varieties and 13 cultures were tested against suitable standards in two replicated trials. The results are summarised below :

Early duration trial.—Two varieties *viz.* Ac.517 and GS.741 and two fixed cultures from Ch.45 × Ac.1951 combination were tried against the standard Ch.45. The cultures gave increased yield over the standard Ch. 45 (1378 kg/ha) but the differences were not significant. These cultures are non-lodging and have yielded 1465 and 1386 kg/ha.

Mid late duration trial.—Eleven fixed cultures (7 from T.141 combination, 2 from Bam 9 combination and one each from Ch.45 and T.90 combination) along with their parents were tested in this trial. The parent T.141 was used as a standard. No culture was significantly superior T.141 which gave a yield of 3099 kg. per hectare; however, two cultures *viz.*, T.141 × Ac. 1951-17 and T.141 × Ac. 1951-22 gave increased yield (3300, 3205 kg/ha respectively) over the high yielding parent T.90 (3197 kg/ha). Bam 9 gave only 2012 kg per hectare. The high yielding cultures are also non-lodging.

Progeny row trials.—Eighty-nine cultures from nine cross combinations involving non-lodging (Ac.517, Ac.1951, GS.130, GS.106) and lodging varieties (T.141, T.812, Ptb.10, T.1242 and Triple cross) were grown in the F_5 generation.

The early cultures from combinations Ptb.10 × Ac.1951, Triple cross-× Ac.517 and T.812 × Ac.517 were badly affected as a result of submergence under water. Three cultures from the combination (T.141 × Ac. 1951) gave increased yield (4406, 4124 and 4086 kg/ha) over T.141 (4031 kg/ha). Based on non-lodging habit, number of ear-bearing tillers and other morphological characters 426 field selections were made.

F_6 generation.—In the trial in F_6 generation 193 cultures from 20 cross combinations were included. Seven cultures from two combinations *viz.*, T. 90 × GS. 113 and T.90 × GS. 130 yielding 2118 to 2949 kg/ha were significantly superior to their respective high yielding parent. A total number of 887 field selections was made in the material for laboratory studies.

F_7 generation.—Thirty-nine cultures from 9 cross combination were included in this trial. The non-lodging parents are Ac.1951, Ac.517, GS.220, Nam-dok-mai and Puang-nak. The parents T.141, T.90, Bam 9 and T.1242 were also included in the trial.

Seven cultures from 3 combinations gave increased yield (2226 to 3120 kg/ha) over their respective high yielding parent. Three hundred and fifty selections were made in this trial. The flowering of the cultures were uniform.

Morphological studies in parents and fixed hybrids :

In order to ascertain the relationship between diameter and breaking strength of the culm and the lodging behaviour, studies were made in ten random samples obtained from lodging and non-lodging material. The data are presented in Table XXVII.

TABLE XXVII

Culm diameter and breaking strength of types and fixed cultures

Sl. No.	Lodging behaviour	Name of the variety or culture	Mean diameter of the culm (in mm)	Mean breaking strength of the culm (in gms)
1	Lodging	Ch.45	3·17	137·0
2	Lodging	T.141	4·57	512·0
3	Lodging	Bam 9	5·89	522·6
4	Non-lodging	Ac.517	7·70	1283·1
5	Ditto	Ac.1951	6·44	631·0
6	Ditto	Ch.45 × Ac. 1951-46	4·56	315·6
7	Ditto	T.141 × Ac.1951-23	5·89	733·5
8	Ditto	Bam. 9 × Ac.517-10	6·23	533·2

The available data indicate that neither of the two values when considered separately could be taken as a criterion for evaluating the non-lodging behaviour. In general, however, non-lodging varieties possess a higher breaking strength and increased culm diameter than that of lodging varieties.

An experiment was laid out in a split plot design to test the response of varieties to fertilizer application and their lodging bahaviour. No data on yield were collected as the plots were badly affected as a result of submergence under water. It was however noticed that C 30—28 a variety from Burma was able to tolerate submergence under water without much reduction in yield.

V. *Survey of the flora of Oryza species for useful genes*

Seeds of 31 varieties were added to the collection from Assam and Tripura. A large number of *spontanea* forms and one sample of *Hygroryza aristata* were also collected from this area by the Director. The collection suggests that this locality is rich in varietal diversity. Studies in the material have been initiated. *Hygroryza aristata* was also collected from Cuttack. Seven *spontanea* forms and 2 *perennis* types were collected from Mysore and Kerala. A form of *O. perennis* was also collected from Coimbatore.

VI. *Embryological studies*

Embryological studies in a multipistillate variety Ac.1225 were carried out. It has been observed that the increased number of ovaries in the spikelet is due to the division of the ovary initial. The number of kernels in the grain depends on the stage at which the branching occurs.

The sterility observed in the panicle is due partly to the improperly filled pollen grains (sterile) and partly to abnormally developed and branched ovaries. The different types of branching and the abnormalities in the development of the ovary have been recorded.

Studies carried out in triploid hybrid between a diploid variety of *O. sativa* and the tetraploid *O. alta* showed that the development of anther wall layers is normal ; however the microspore mother cell does not form mature pollen grain. Instead, the tapetal cells elongate and finally degenerate. Likewise, the nucellus and the megaspore mother cell degenerate and consequently no functional embryo sac is formed.

Embryo culture:

Work on embryo culture was intensified. By this method it was possible to grow partially developed grain and 5 to 6 days old embryos. Crossed seeds (partially filled) obtained from inter-specific crosses were grown successfully in many instances by this technique.

An attempt was made to find out the influence of medium (pH) on the growth of embryos in the initial stages. It was observed that the embryos had a slower rate of growth at neutral medium than at either acidic or alkaline medium.

Anatomical studies:

Anatomical studies were carried out in the sterile and fertile glumes of different varieties in the cultivated species *O. sativa* and in a few other wild species.

Normally, there is only one vascular bundle in the sterile glume but this number is variable. Thus in an Indonesian variety *Baok* there are 3 bundles in each glume and in *O. stapfii* a wild species obtained from Africa; this number varies from 5 to 7. The presence of increased number of vascular bundles suggests that the glumes are only reduced lemmas.

The lemma and palea have respectively 5 and 3 vascular bundles corresponding to the number of nerves. Serial sections obtained from the rachilla to the spikelet show that the different vascular stands arise independently from the main vascular strand.

Differences in the anatomical structure were observed between the lower and upper regions of the leaf sheath. At the basal region, the air cavities are small and the connecting bands are wider. The number of layers of parenchymatous cells below the upper epidermis in this region is more than in the upper region.

Anatomical studies in O. brachyantha.—In the developmental studies conducted in the wild species *O. brachyantha* it was noticed that the first tiller exhibits a trailing habit. This tiller soon dies and the tillers that arise subsequently are normal. Corresponding anatomical differences were noticed between the first tiller and the subsequent tillers. The first tiller exhibits several anatomical features of a hydrophyte. The air cavities are large and the-2 ringed arrangement of the vascular bundles in the internodal region as is commonly found does not occur in the first tiller.

VII. *Collection and identification of rice weeds*

Nine species have been identified. With this collection, 34 species belonging to 14 families have been collected, identified and preserved in herbarium sheets. The names of the species identified and the families to which they belong are given below :

Name of species	*Family*
Imperata aurundinacea . . .	Gramineae
Mnesitha perforata	Ditto.
Kyllinga triceps	Cyperaceae
Scirpus articulatus	Ditto.
Eleocharis plantagenia . . .	Ditto.
Panicum proliferum . . .	Gramineae
Brachyraria mutica	Ditto.
Leersia hexandra	Ditto.
Eriocaulon quincangulare . .	Eriocaulaceae

VIII. *Jeypore Botanical Survey*

Data on the height of plants, total number of tillers, total number of ear-bearing tillers and duration of the varieties were recorded for 1,500 types. A large number of varieties which have a high ear-bearing tiller potential is now available in the collection which could be utilized in breeding programmes. Fifty varieties in the early duration group, 88 in the medium maturity group and 12 in the late group have ear-bearing tillers ranging from 15 to 23.

Fifty-four varieties from the Jeypore collection comprising 34 with *japonica* type of grains and 20 with *indica* type of grains were tested for their phenol reaction and for KOH test. The phenol reaction is intended for studying the colour reaction of grain when treated with 1·5% aqueous phenol-solution while the latter is meant for the study of endosperm hardiness. None of the varieties tested showed any colour change with phenol. The varieties however differed in their reaction to KOH solution. Varieties with *japonica* type of grains showed a higher degree of endosperm disintegration (such as true *japonicas*) than those with *indica* type of grains.

Selection for high fertility in induced auto and allo-tetraploids :

Selection for high fertility in induced auto tetraploids of GEB.24, SR.26B, Seta and Indrasail and in gamma irradiated autotetraploid of SR 26B was done. The criteria of selection were number of ear-bearing tillers, length of the panicle, spikelet fertility and density of panicles. A large number of single plant selections was made.

The spikelet fertility in the induced tetraploids varied from 50 to 65 per cent. In some cultures in G_2 population of auto-tetraploid SR.26 B the spikelet fertility was as high as 75%.

IX. *Cytology*

The details of taxonomic characters of the species were tabulated and a revision in the taxonomy of the genus has been suggested. The inter-relationship of the species within the genus has been discussed.

One of the changes proposed is the merging of three tetraploid American species, *O. latifolia*, *O. alta* and *O. grandiglumis*. Previous work had shown that *O. latifolia* and *O. alta* are interfertile and their progeny segregates for characters separating the species. The current year's work showed that *O. grandiglumis* is interfertile with *O. alta* as well as *O.latifolia*. F_2 generations of these hybrids are being grown. In the hybrids, *O. grandiglumis* × *O. alta* and *O. grandiglumis* × *O. latifolia* the character of increased size of glume (sterile lemma) is recessive to that of short size, similar to the mode of inheritance in *O. sativa*.

One other change proposed is to merge the two African species, *O. breviligulata* and *O. stapfii* into a single species. Evidence for the close relationship of the two species has now been secured. The two are interfertile. They have sympatric distribution. Natural populations show continuous variation in awn size and spikelet size, the two characters used in discriminating the two species. Information available leads to the inference that these two species have different ecological adaptations, and therefore they can be grouped as varieties of *O. breviligulata* which specific name has priority.

Studies in variation and race formation in the species *O. officinalis* has been continued. The collections of this species are from the following regions: Gujerat, Ceylon, Burma, Thailand, Borneo and China. Thai and Viet Nam varieties resemble each other closely, but the other collections are distinct enough to be termed geographical varieties. Previous observations had shown that semisterility occurred in hybrids between varieties. Hybrids between Borneo and Gujerat varieties are being grown. A natural cross in the Ceylon variety showed semisterility.

Origin of cultivated rices:

The collection of *O. perennis* and *Spontanea* varieties was studied for their taxonomy and inter-relationship. There was continuous variability from typical *O. perennis* to *O.spontanea* and delimiting either group, was difficult. This is inferred to be caused by natural hybridisation, accompanied by segregation.

The Asian forms of *O. perennis* were characterised by spreading habit by rooting and branching at nodes, by long anthers and by long slender grains. The *spontaneas* in general are annuals with semi-erect habit, short anthers and bold grains. The last feature is attributable to presence of genes from cultivated rice. Linking the two types were collections from Ceylon and Cambodia, which had spreading branching habit of *O. perennis*, as well as the bold grains of *Spontaneas*. The Ceylon form was highly sterile. Examination of local wild rice populations showed that plants morphologically like *O. perennis*, had high pollen as well as spikelet sterility. This is supported by the features of a Malayan wild rice which had the habit of cultivated rices, but grains resembled those of *O. perennis* and was highly sterile.

The African types of *O. perennis* are identifiable by their tall erect habit and vigorous branched rhizomes. Since they are distinct morphologically and are geographically isolated, these can be given a specific rank namely *O. barthii*.

New collections from Mali Republic and Central Africa showed increased range of variability as compared to the previous collections from Sudan and Madagascar. The differences were in the habit as some of the Mali plants are weak or have procumbent growth thus resembling Asian *O. perennis*.

The plants showed degrees of pollen sterility and the next generation is to be examined for heterozygosity. A hybrid between *O. barthii* and a variety of *O. sativa* (Triploid progeny) was grown and this showed partial seed setting. This indicates homology of chromosomes between the two species.

The typical African wild rice *O. breviligulata* (sensu latiore) has short ligules like the African cultivated rice *O. glaberrima*. A wild rice from Badeggi, West Africa, had long ligules, bold grains and was semisterile, thus resembling some Asian *Spontaneas*. The affinities of this type is being tested by hybridisation with other wild rices.

Another wild rice from Amazon Basin, South America resembled Asian *Spontaneas*, but had flattened grains with long awns thus resembling those of *O. breviligulata*. The affinities of this type are also being tested.

The hybrid progeny of Orissan type of *O. perennis* (var. *Balunga*) and a Cuban type (var. *Cubensis*) was advanced to F_7 generation and selections made for plants suitable for cultivators. To improve the scope for selection, irradiation by Gamma rays had been done, and G_2 generation grown. Selections were made from these also. In contrast to this combination *O. perennis* var. Balunga × *O. glaberrima* Combination in F_6 generation gave *Spontanea* like plants which retained semisterility, long awns and grain shedding character and were thus unsuitable for cultivation.

Evolution of cultivated rices :

These basic studies of wild rice had shown that natural crossing between wild and cultivated rices has been taking place in many parts of the world. This generalisations leads to the inference that *japonica* subspecies of rice arose by introgressive hybridisation. From available data, a hypothesis that *japonica* subspecies arose by human selection from hybrids between Chinese *indica* rices and *O. perennis* var. Formosiana has been put forward.

Chromosome variants in rice :

From one irradiated stubble of a haploid rice, two clones were isolated and multiplied. From these two clones, homozygous diploid seeds were secured by natural chromosome doubling. From these seeds two cultures A and B are being grown for a study of chromosome structural variation.

The isolation of anenploid plants from progenies of a triploid plant is being continued. The plants tend to be 24,25,26 or 27 chromosomed. There is an excess of 26 chromosomed over 25 chromosomed plants. One plant with the chromosome number 43 was also secured. The identification of the anenploids is being done by study of meiosis. The pachytene stage of meiosis is being used to identify the nature of extra chromosomes. Crossing the anenploid plants with diploid rice varieties having marker genes has been started.

X. *Other investigations*

Irradiation studies :

(i) Eight cultures derived from Ptb. 10 (irradiated with X rays) were tried against Ptb. 10 in a replicated trial. The cultures were badly affected and the seeds of the cultures have been collected for conducting trials during next year. The cultures were sent by Dr. K. C. Bora from Bombay.

Irradiation of varieties for inducing mutations.—In the N_4 generation of irradiated As. 35, a dwarf mutant was obtained which appears promising. Ways and means for the utilization of this mutant are being explored and studies are in progress.

Another population in G_2 generation (Gs. 137) was also studied. A plant with a chimeral structure was isolated. This particular plant was propagated by tiller planting technique. The tillers with yellow and green stripes did not survive. The plants in the population showed variation for panicle density and height.

In the G_2 generation of an irradiated long glumed variety Ac. 2749, two plants were isolated which had normal glumes. Probably this had arisen as a result of dominant mutation.

In the G_2 generation of three other varieties *viz.*, Ac. 3243, JBS. 809 and Ac. 1778, easily detectable mutations were not met with.

(ii) A new line of work has been started concerning pollen morphology. As a beginning, the pollen morphology of 21 species and some varieties in the cultivated species was studied. Seventeen characters were considered in this investigation; Of these, 11 were found to be common for all the species and varieties. On the basis of the remaining 6 characters *viz.*, shape, polar diameter, equatorial diameter, size of the aperture, shape of the rim and its size a classification of the different species in the genus was attempted. Evidence suggest that there has been an increase in pollen volume as a result of polyploidy. The species *O. ridleyi* however, is an exception. The evolutionary relationship of the pollen grains within the genus *Oryza* has been considered.

(iii) Work initiated in 1959 on the technique of clonal propagation in rice was intensified, a reference to which has also been made under the report of the Farm Division.

XI. *Scheme for the evolution of japonica × indica hybrids and their utilisation in the different regions*

The report pertains to the second year of the scheme, sanctioned in February, 1960. Out of the eleven units, ten have been established one each in Kerala (Trichur), Mysore (Nagenhalli), Andhra Pradesh (Maruteru), Orissa (Bhubaneswar), West Bengal (Chinsurah), Bihar (Patna), Uttar Pradesh (Faizabad), Madhya Pradesh (Jabbalpore), Assam (Titabar) and Kashmir (Lalmandi). Arrangements are on way for the establishment of the eleventh unit.

While the field staff for almost all units have been recruited, the Assistant Botanist for Bihar and the eleventh unit are yet to be appointed.

(a) *Introduction of types :*

Among the *japonica* types tested, Norin-20 is doing well in Maruteru, Titabar, Jabalpore, Trichur and Chinsurah, Norin 18 in Trichur, Faizabad and Chinsurah, and Norin 1 in Titabar, Nagenhalli and Chinsurah. Taichung 65 of Taiwan and W. 131 of Indonesia do well in Maruteru, Nagenhalli and Chinsurah; Taichung 65 does well in Faizabad and W. 132 in Kerala.

(b) *Trial of japonica × indica fixed hybrids :*

Out of the fixed hybrids (evolved at this Institute) tried under different levels of fertility (20 lbs., 40 lbs., 60 lbs. and 80 lbs. N), the following have been found to show increased yield response to progressively heavy manuring at the places indicated against each :—

(i) BAM. 9 × Rikuu 132	Maruteru.
(ii) BAM. 9 × Norin 18-7 T. 442 × Aikoku-19	Nagenhalli.
(iii) T. 1145 × Asahi T. 1145 × Taihoku T. 812 × Asahi T. 90 × Norin 23	Bhubaneswar.
(iv) Norin 6 × GEB. 24 GEB. 24 × Norin 1	Trichur.
(v) T. 1145 × Norin 36 T. 1145 × Taichung 65	Chinsurah.
(iv) Norin 6 × GEB. 24 T. 812 × Asahi BAM. 9 × Rikuu 132	Faizabad.

(c) *Trial of intra-indica fixed hybrids :*

Six fixed hybrids, which are high yielding and of early duration, were evolved at this Institute and sent for testing at the various state units. Strains C. R. 1, C. R. 3 and C. R. 4 have been found to be superior to the local standards in various centres (*viz.*, Maruteru, Chinsurah, Titabar, Patna, Jubbalpore and Trichur) and thus appear to be of cosmopolitan nature.

(d) *Hybridization programme :* 15

Considering all the centres, the following crosses have been effected; the crossed seeds of these will be grown in the next season.

(i) *Japonica* × *indica* . . .	31
(ii) *Japonica* × *javanica* . . .	5
(iii) *Japonica* × *Taiwan* . . .	4
(iv) *Taiwan* × *indica* . . .	7
(v) *Indica* × *javanica* . . .	8
(vi) Other miscellaneous cross combinations	6

(e) *Selection :*

1150 selections at various generations for high response to manuring have been made in different units.

F_2 for F_3—96
F_3 for F_4—412+249=661
F_4 for F_5—722

(f) *F_1 generation :*

Crossed seeds of ten cross combinations were grown and the F_1 seeds for growing F_2 generation have been harvested, after the detailed observations of the various morphological characters were recorded.

(g) *Other items of work :*

(i) In Assam, 11 wild types, 1 hill paddy and 33 cultivated types have been collected. In Mysore, two wild types have been gathered.

(ii) C. R. 3 has been found to be eminently suited to vegetative propagation at Maruteru.

(iii) Kamod 118, Kampeikovi, Putta butta, Yelkerisal, S. 1079 } have been found to be resistant to Helminthosporium at Chinsurah.

(iv) Mugad 249, Yelkerisal, Abur Sauva, BCP. 9, Jogerina selections (S. 661 & S. 710) } have been judged to be good promising strains for direct introduction at Chinsurah.

(v) For swampy conditions, the hybrid (Baok × Buntar) at F_5 generation was grown at Bhubaneswar and 71 high yielding selections made.

(vi) *Developmental studies.*—Three varieties (*viz.*, PTB. 10, Norin. 17 and Taichung 65) were observed for developmental studies. At Bhubaneswar, it is recorded that tillering started in all the varieties in the 4th week and attained its maximum in the 6th week.

At Maruteru, it is seen that in regard to height, the rate of development of all the three varieties is identical upto 60th day from the date of sowing, when it attains the height of 65 cms. Thereafter, the rate of development becomes slow in Norin 17, moderate in Taichung 65 and very rapid in PTB. 10. Considering the different components of yield, Taichung 65 seems to have struck a compromise between Norin 17 and PTB. 10 and seems to give the best performance.

(vi) The javanica type, W. 131 did not flower until December in Trichur. In Jubbalpore, Ac. 1951 and Javanica types Solo-110, Djambu and Baok did not yield any grain

(viii) Hsinchu and W. 449 have proved to be non-lodging and high yielding at Faizabad.

XII. *Central Saline Resistant Rice Research Station, Canning Town.*

1. *Maintenance of Genetic Stock :*

To the existing collection of 92 varieties, 228 varieties from different states and different villages round about the sub-station were added.

2. *Trial of promising varieties under different levels of fertilization :*

Eighty promising varieties were divided into three duration groups (*viz.* 121-130 days, 141-150 days and 151-160 days). The levels of fertility used were (i) 40 lbs. N and 32 lbs. P_2O_5, (ii) 60 lbs. N and 48 lbs. P_2O_5. Six varieties of the medium duration have shown some response to manuring and hence these varieties will be tested next year more elaborately.

3. *Training of plants to tolerate salinity :*

(a) Fifty varieties were raised and saline irrigation water from the adjoining river was applied once every week (1000 c.c.s) until the initiation of flowering. Three varieties gave more yield than the control. The progenies of these plants will be grown next year under similar conditions.

(b) The seeds of the progeny of one plant that survived in 1961 season even after receiving saline irrigation of the type described above were sown and the progeny harvested. These will be again sown in the next season.

(c) Autotetraploids of S. R. 26 B (a saline resistant variety) when grown under saline water irrigation died before flowering. The tetraploid has proved to be more delicate than its diploid.

4. *Secondary selection :*

19 secondary selections showing greater tolerance to salinity than the parental S. R. 26 B (normally saline resistant variety) made during 1961 season were grown and further 133 single plant selections made. This is the second year of selection.

5. *Hybridization programme :*

The F_1 hybrids of (i) S.R.26B × *O. sativa* var. *spontanea :*

(ii) S. R. 26 B × Geri

(iii) MTU. 15 × S.R. 26 B

were grown and the first two were lost due to failure of the seeds to germinat F_1 seeds of the third combination and those of S.R. 26B × *O. sativa* var *spontanea* (obtained from C.R.R.I.) for growing F_2 generation in the next season were collected.

Fresh crosses have been made and the crossed seeds will be sown in the next season.

6. *Studies on seed dormancy and loss of viabi ity :*

1000 grains of each of four varieties (*viz.*, MTU. 15, Jhona-349, MTU. 9 and Bhurra rata 4-10) were dried to constant weight immediately after the harvest of the winter crop.25 seeds were sown per lot in three repl cations from each variety. These sowings were continued at monthly intervals until the viability is judged to have been lost.

The same procedure was adapted for the seeds of these varieties harvested from the Boro crop. Experimental results are furnished in Table XXVIII

TABLE XXVIII

Varieties	Seeds from aman crop	Seeds from Boro crop
MTU. 15	No dormancy (100 % germination)	Partial dormancy (80% germinatien)
MTU. 9	No dormancy (100% germination)	Partial dormancy (46·7% germination)
Jhona 349	Partial dormancy (80% germination)	Partial dormancy (37·3% germinatien)
Bhurra Rata-4-10	Partial dormancy (70% germination)	No dormancy (94·7% germination)

Thus the same variety, when grown in different seasons show differential behaviour in respect of dormancy. The viabil ty of the seeds from the Boro crop was lost much earlier than those from the aman crop.

7. *Trial of green manure crops :*

Out of the sixteen green manure crops tried, all the species of the genus Sesbania *viz.*, *Sesbania sericea*, *S. aculeata*, *S. macrocarpa* and *S. speciosa* have proved to be quite suitable for saline soils. These observations need further verification in the next season.

8. *Varietal resistance to rice hispa :*

Twenty rice varieties grown in four replications were observed for the prevalence of *hispa*, with a view to determine the relative difference in susceptibil ty among different varieties. Prel minary observations indicate a low incidence of hispa in MO-1, MTU-15, Dodakare and SR. 26B and high incidence in Sitasail, SLO-13 and Rupsail local. These results need confirmation.

CHEMISTRY

I. *Investigations on nutrient availability in waterlogged soils*

1. *Transformations of nitrogen in water-logged soils :*

Transformations of nitrogen, applied to the water-logged soil at the rate of 25 ppm. N, as ammonium sulphate, ammonium chloride and urea, was followed up under laboratory incubation conditions. Data on the total nitrogen and mineral nitrogen contents of soil in the different treatments at different incubation periods are summarized in Table. XXIX.

TABLE XXIX

Total and mineral nitrogen content of soil at different incubation periods
(mg N/100 gm soil)

Fertilizer	Form of N	Period of incubation (days)					
		10	20	30	40	50	60
Control .	Total N . .	77	76	92	76	83	83
	Mineral N .	10·6	8·9	7·8	7·3	5·9	5·9
$(NH_4)_2 SO_4$	Total N . .	87	84	96	73	83	82
	Mineral N .	10·8	8·5	8·2	6·2	6·1	5·1
NH_4Cl .	Total N . .	87	95	86	75	72	83
	Mineral N	11·5	10·1	8·1	7·8	6·3	6·0
$NH_2 CO.NH_2$	Total N	86	78	82	76	71	82
	Mineral N .	10·8	9·0	7·7	6·9	6·2	5·6

Results show that there was no difference in the mineral nitrogen content of soil between the treatments for each period of incubation. The mineral nitrogen content decreased as incubation proceeded. The total nitrogen content on the other hand increased upto 20 to 30 days incubation, possibly due to microbial assimilation or immobilization of mineral nitrogen. After 30 days, there was again a decrease in the total nitrogen content. From the trend of results, it has not been possible to draw out any definite conclusions. The experiment is being modified and worked out in greater details.

2. *Phosphorus fixation and transformation in water-logged soil :*

A preliminary laboratory study was taken up to follow the fixation and transformation of phosphorus applied as $KH_2 PO_4$ in water-loggged soils. The preliminary work involved mostly in standardizing techniques of experimentation. Results show that absorption of applied phosphorus obeyed the Freundlich isotherm.

$$\frac{X}{m} = kc^{\frac{1}{n}}$$

The cation exchange capacity of the soil increased due to absorption of H_2PO_4 on the soil complex. Detailed experiments on phosphorus fixation and transformation have just been started.

3. *Effect of nitrogen application on the release of cations from the soil :*

Influence of application of increased amounts of nitrogen as ammonium sulphate on the displacement of Ca^{++} and Mg^{++} from the soil complex was investigated in a laboratory experiment. The soils were leached at periodical intervals and Ca^{++} and Mg^{++} content in the leachates were determined. Results are summarised in table XXX.

TABLE XXX

Influence of Nitrogen application on the displacement of different cations in the soil

(Cations m.e. in leachate of 250 ml)

Level of nitrogen (PPM)	Cation	1st leaching (after 1 week)	2nd leaching (after 2 weeks)	3rd leaching (after 3 weeks)	4th leaching (after 4 weeks)	Total
0	Ca++	0·27	0·04	0·07	0·06	0·44
	Mg++	0·32	0·08	0·04	0·09	0·53
50	Ca++	0·94	0·11	0·07	0·06	1·18
	Mg++	1·02	0·28	0·10	0·08	1·48
100	Ca++	1·38	0·11	0·11	0·08	1·68
	Mg++	1·12	0 37	0·11	0·08	1·68
150	Ca++	1·54	0·13	0·11	0·08	1·86
	Mg++	1·14	0·32	0·10	0·08	1·64
200	Ca++	1·61	0·13	0·16	0·08	1·98
	Mg++	1·45	0·32	0·14	0·07	1·98

Results show that application of nitrogen in increasing levels to the waterlogged soils displaced considerable amounts of Ca++ and Mg++ from the soil complex. On a consideration of equivalence, the magnitude of displacement in respect of both Ca++ and Mg++ was more or less same. The scope of the experiment is being extended to study the influence of different nitrogen carriers like ammonium sulphate, ammonium nitrate and urea on the displacement of cations specially Ca++, Mg++, K+, Mn++ and Fe++ both in the presence and absence of the rice crop.

II. *Investigations on nutrient assimilation by the rice plant*

1. *Effect of deficiency of macro-nutrients :*

Foliar diagnostic symptoms of deficiency of N,P,K, Ca and Mg in the rice plant have been observed and recorded. Plants deficient in the respective nutrients were obtained in solution culture. Ca deficiency appeared difficult to show up. It has been possible to make a definite distinction between the symptoms of N, P, K, and Mg deficiency, both from the colour of the young leaves as well as the dead leaves at all growth stages upto booting. The differences are summarized in table XXXI.

TABLE XXXI

Distinguishing features of N, P, K, and Mg deficiency in old and new leaves of the rice plant

Plant deficient in	Appearance of		
	Old dead leaves	Middle leaves	Upper leaves
Nitrogen	Orange yellow.	Yellowish green.	Yellowish green.
Phosphorus	Purplish red.	Bluish green.	Deep bluish green.
Potassium	Dirty yellow due to the presence of brown spot.	Interveins yellow with veins green.	Deep green.
Magnesium	Puffy yellow.	Interveins yellow with veins, specially the mid-rib bluish green.	Looks like that of a normal plant.

Deficiency of nitrogen, phosphorus and potassium brought about a considerable reduction in grain yield where as with calcium and magnesium deficiency only slight reduction in grain yield was obtained.

2. *Phosphorus nutrition of the rice plant :*

A solution culture experiment was conducted with two *indica* rice varieties Ptb. 10 (110 days) and T. 141 (150 days) to study the efficiency of phosphorus absorbed at different stages of growth of the plant for production of grain. Phosphorus levels used were 2 PPM P (Low) and 10 PPM P (Optimum). Grain yield data are given in table XXXII.

TABLE XXXII

Efficiency of phosphorus absorbed at different growth stages for production of grain

Variety	Level of P	Yield gm/pot	Period of P absorption (days after planting)								
			0	10	20	30	40	60	70	80	100
Ptb. 10	2 ppm	Grain	0·6	6·1	15·6	22·0	23·1	..	23·2	..	..
		Straw	3·7	14·7	24·5	24·3	25·7	..	24·3	..	..
		Root	1·8	5·4	6·7	6·9	6·4	..	5·8	..	..
	10 ppm	Grain	0·6	6·7	22·3	22·6	23·6	25·8	29·4	..	..
		Straw	3·7	15·4	25·8	24·6	23·5	25·4	28·6	..	..
		Root	1·8	5·4	7·7	4·8	5·8	5·0	6·4	..	..
T. 141	2 ppm	Grain	0·2	5·1	17·3	24·7	32·7	33·2	35·1	37·0	39·4
		Straw	3·5	21·2	45·2	45·7	49·1	45·2	47·8	48·2	47·5
		Root	2·2	12·2	20·3	18·7	17·6	12·1	11·3	13·3	13·2
	10 ppm	grain	0·2	4·0	29·3	35·6	35·7	37·6	..	38·6	39·4
		Straw	3·5	17·6	52·6	50·6	51·3	49·3	..	47·5	48·8
		Root	2·2	10·5	22·6	16·1	17·3	14·2	.	15·3	8

Results show that in the case of short duration variety Ptb. 10, at low levels of P, Phosphorus absorbed upto 30 days after planting was adequate to give an optimum yield where as at optimum level of P supply, this was obtained at about 20 days after planting. In case of T. 141 the period of absorption had to be advanced for another ten days at corresponding P levels, to get an optimum yield.

These results indicate that phosphorus absorbed during the tillering stage of the plant was most efficiently utilized for production of grain. In practical agriculture, a short duration variety, from these evidences, should need phosphorus fertilization at planting where as a longer duration variety might benefit more by application of phosphorus about 2 to 3 weeks after planting.

3. *Role of antibiotics and vitamins in plant growth :*

Effect of vitamins, thiamine and ascorbic acid and antibiotics chloromycetin, aureomycin and achromycin on the germinating rice seeds was investigated. Favourable root elongation was observed with ascorbic acid. Studies with the antibiotics at concentration ranges from 1 to 40 ppm were undertaken both in nutrient solution and tap water. Marked depression in root elongation was observed even at 1 ppm concentration of the antibiotics.

4. *Role of manganese on the growth of rice plant :*

A solution culture experiment was conducted to study the effect of increasing levels of Mn from 0 to 100 ppm on the growth, yield and composition of the rice plant. There was great contamination due to excessive rains in August and so no conclusive results could be obtained. The experiment is being modified and repeated.

5. *Response to high fertilizer application by different rice varieties :*

(a) A pot experiment was conducted to study the response to high fertilizer application by single plant selections of a *japonica* × *indica* tetraploid-*japonica* × *indica* mutant, *japonica* × *indica* deploid, *indica* tetraploid, *indica* diploid and two *glaberrimas*. Levels of nitrogen used were 0, 1 and 2 gm nitrogen per pot containing 20 Kg soil, corresponding to 0, 100 and 200 lb. N per acre. Yield data are summarised in Tables XXXIII.

TABLE XXXIII

Response by different rice varieties to high fertilizer application
Grain yield gm/plant

Variety	No Nitrogen	1 gm nitrogen per pot	2 gm. nitrogen per pot
Japonica × *indica* (Tetraploid)	5·7	7·4	12·2
Japonica × *indica* (mutant)	16·8	30·7	38·6
Japonica × *indica* (diploid) long sterile glume	9·0	19·4	31·0
GEB. 24 (tetraploid)	8·7	18·2	24·4
GEB (Low N selection)	18·0	32·8	40·8
GEB (High N selection)	16·6	29·7	38·8
Glaberrima (1)	13·9	23·6	24·1
Glaberrima (2)	11·1	13·5	20·8

Results show presence of response to application of higher doses of nitrogen in all the cultures tested except in one of the two cultures of *glaberrimas*.

(b) Investigations on the genetics of high fertilizer response in rice initiated earlier have been continued.

III. *Fertilizer-soil-water relationship in rice*

1. *Utilization of applied nitrogen in relation to time of application :*

A field experiment to study the utilization of applied nitrogen by the rice plant in the ammonium and nitrate forms, in relation to level and time of application was taken up. There was crop failure due to heavy floods in August. The experiment was replanted and the replanted crop suffered because of lack of water at later stage. Yield data will not possibly be correct to warrant any definite conclusions.

IV. *Study of physical properties of rice soils*

1. *Technique of measuring the degree and depth of soil puddle :*

A field experiment was conducted in collaboration with the Agricultural Engineering Division to evolve a suitable technique of determining the depth and degree of soil puddle. The depth of puddle could be measured from the distance penetrated by a penetrometer under a force which could just overcome the resistance of the puddle. The degree of puddle was found to be a function of settling depth of the soil subjected to a uniform centrifugal force. Different bullock drawn puddling implements were compared and the Orissa Duck foot plough was found to be most suitable under wet-land condition.

Entomology

I. *Varietal susceptibility investigations*

(a) *Gall fly : Pachyndiplosis oryzae* (W.M.) Mani :

Four hundred and seventy-nine varieties from the FAO collection of World Genetic stocks maintained at this Institute, were examined for their relative susceptibility to gall fly prior to the flowering of the varieties. Thirty six varieties out of which twenty-seven had flowered before the peak period of infestation had shown no incidence. The frequency distribution of the percentage infestation in the varieties is given in the Table XXXIV.

Table XXXIV

Table showing the frequency distribution of the percentage incidence by gall fly

Range of incidence	Duration groups			Total No. of varieties
	60 to 80 days	81 to 100 days	101 to 125 days	
Nil	27	7	2	36
0·1 to 5·0	38	17	3	58
5·1 to 10·0	18	41	11	70
10·1 to 20·0	4	88	93	185
20·1 to 30·0	..	24	87	111
30·1 to 40·0	..	2	14	16
40·1 and above	..	1	2	3
Total	87	180	212	479

(b) *Stem borers :* Schoenobius incertulas *Wlk.*, Scirpophaga innotata *Wlk.*, Chilo oryzae *Linn.*, Chilotraca (Proceras) Polychrysa *Meyer and* Sesamia inferens *Wlk.* :

As in the previous year, investigations on the reaction of rice varieties to stem borers was studied in a group of 31 second season varieties grown in a randomized block with the variety PTB. 10 as a standard. The susceptibility to stem borers was assessed by drawing and examining samples at two stages of crop growth *viz.*, at the early growth phase and at the heading phase.

The percentage of borer infested tillers ranged from 45.72 in Ac. 1951 to 25.78 in Ac. 1368, while the standard variety PTB. 10 showed 34.12 per cent infested tillers. At the heading phase the percentage of borer infested ear heads ranged from 41.67 in variety Blue-bonnet 50 to 3.33 in the variety T.K. M. 6 while the incidence was 14.32 per cent in the variety PTB. 10. The varieties like T. 657, TKM. 6, C.B.I, MTU 15 showed a fair degree of resistance at both the early growth phase and at heading phase while varieties ASD. 2, CH.4 & Blue bonnet 50 showed a high degree of susceptibility at both the phases.

The results are in conformity with those obtained in the previous year.

(c) *Hispa :* Hispa armigera *Oliv :*

In an investigation on varietal reactions to rice hispa, a group of twenty varieties grown under normal fertility level of soil at the C.R.I. Saline Substation, Port Canning were examined for five times at intervals of a fortnight for assessing the degree of infestation and for the population of beetles. The varieties are classified on the average of total population of beetles taken in sweeps on all the five dates of observation as under. It may be mentioned here that the same degree of susceptibility was not observed in the previous year. This needs to be confirmed.

TABLE XXXV

Table showing the population of beetles in the varieties

Below 1·0 Low	1·1 to 1·5 Moderate	1·6 and above high
Rupsail local	Sitasail.	Badshahbhog.
Patnai-23	Mtu. 15.	Doddakhare.
T-23	Budamologolukalu	C-100-22.
M.0·1	C.R.H. Rupsail.	Bontha akkulu.
C-100-34	Kanakchur	SLO. 13.
Asbata	Nizersail.	Marichsail.
	SR. 26 B.	Kumargore.

II. *Insect resistance in rice*

(a) *Resistance to gall fly :*

(*i*) From the data collected in the previous year it was found that the incidence by gall fly is higher in the diploid than in the tetraploid strains of rice varieties. The observations were repeated in diploids and tetraploids of the varieties Seta, GEB. 24 and Indra sail and it was confirmed that in all the autotetraploids the gall fly infestation was lower than in the respective diploid strains.

(*ii*) In order to investigate the degree of resistance to gall fly in the wild types of rices, the available collection of oryza species of wild rices were examined during the peak period for gall fly incidence. The data showed that though there was no resistant variety, the species under section *sativa* were more susceptible than either the species under section *officinalis* or species under section *granulata*. The last mentioned section was least susceptible.

(b) *Resistance to rice stem borers :*

Anatomical characters of the second season varieties which were comparatively susceptible and resistant were studied. In resistant varieties like TKM 6 and W 106 there are more than four layers of highly lignified sclerenchymatous cells. Further, the air spaces are small in such varieties. The highly susceptible varieties are characterised by very big air spaces and have less than four layers with low lignification of sclerenchyma cells.

III. *Incidence of rice pests in relation to agronomic practices*

With the object of determining whether the incidence by gall fly and steem borers depends on the age of crop, the time of transplanting or the season, 30 days old seedlings of two varieties *viz.* CH. 45 and D.I.4 were transplanted at fortnightly intervals commencing from 20-7-61 till 30-12-61. Infestation by gall fly and stem borers was estimated by drawing random samples for twice from each planting *viz.* at 60 and 90 days after planting. Data from only the first five fortnightly plantings was utilised for purposes of analysis as the rest of the plantings were damaged due to the unprecedented floods.

(a) *Gall fly.*—Infestation by gall fly which commenced in the crops transplanted on 20-7-61, extended till the middle of November. Maximum infestation was noticed in crops transplanted during the period from 14-8-61 till 20-9-61. In general, the variety CH. 45 showed higher incidence than the variety D. I. 4 and irrespective of the date of planting, 90 days old crops showed higher degree of infestation than crops at 60 days age. The peak period of gall fly infestation was the middle of October till the middle of November. The peak period for natural parasitisation of immature stages of gall fly was from the middle of October till the middle of November.

(b) *Stem borers.*—Infestation by stem borers was low in the *Kharif* season. The incidence was noted in the crop transplanted on 20-7-61 and examined at 90 days. The crop transplanted on 14-8-61 showed 6·2 per cent dead hearts at 90 days. In general, plants at 90 days age showed higher incidence than the plants at 60 days age.

IV. *Epidemiology of rice pests*

The prevalence and abundance of rice pests were studied to find out the factors favourable for the occurrence of these pests.

(a) *Gall fly.*—Catches of gall flies at light traps indicated that the peak period of prevalence of gall flies was from the middle of October till early November. The mean maximum temperature was 31.0°C and mean minimum temp. was 23.35°C. Average relative humidity during the period was 88.5 per cent.

(b) *Stem borers.*—Catches of stem borer moths at light traps indicated the emergence of a first brood from the middle of January till the middle of February and a second brood from the middle of November till the middle

of December. The following weather conditions were found to exist at the time of brood emergence.

	1st brood	2nd brood
Max. temp.	27·4°C	27·55°C
Min. temp.	16·85°C	14·20°C
R. H.	89·5%	85·5%

V. *Insecticidal trials to control gall fly*

Discarded due to floods.

VI. *Fish*-cum-*Rice culture*

Discarded due to floods.

VII. *Influence of nitrogenous fertilisers on gall fly incidence*

Influence of nitrogenous fertilisers on the incidence of gall fly was studied in an experiment of the Agronomy Division with 25 treatments of the Nitrogenous manures with and without P. & K. Counts of gall fly infestation were taken by random samples in all the 3 replications. The results indicated that the incidence of gall fly increased with the higher levels of Nitrogen whether in the form of ammoniacal nitrogen or ammonium nitrate nitrogen. The incidence of gall fly decreased with the higher levels of phosphate in combination with nitrogen.

VIII. *Effect of Nematode attack in rice and rice soils*

There was a spectacular yellowing of leaves of rice in certain experimental plots. Investigations revealed that nematodes were present both in plants and soils in all cases wherever yellowing was observed. Further work on nematodes is in progress.

IX. *Occurrence and control of rice pests*

There was a light infestation by rice thrips *Thrips oryzae* Will., in the nursery and in the newly planted rice during the months of July and August. Infested crop was sprayed with 0.02 per cent—Folidol or Endrex which effectively controlled the pest.

Leaf hoppers—*Nephotettix apicalis* M., and N. *bipunctatus* F., and the fulgorid *Nilaparvata sordescens* L., broke out as a pest during the months of September and October in ill-drained plots. Spraying Folidol 0.08% or Endrex 0.04% effectively controlled the pests.

A few experimental plots showed moderate infestation by *hispa* which was brought under check by dusting five per cent BHC. Mealy bugs-*Ripersia oryzae* Gr., and root aphids *Tetraneura hirsuta* B., have occurred as sporadic pests on rice. The pests were brought under control by spraying Folidol 0.08%

MYCOLOGY

I. *Study and estimation of resistance to disease in field of the collection of types under genetic stocks*

Observation on disease incidence on the early and medium duration varieties of genetic stocks were continued this year. There was very little disease on the plants either at seedling or later stages of growth.

II. *Helminthosporium disease*

1. *Isolation of resistant varieties :*

(a) *Short duration types from genetic stocks.*—One thousand varieties of genetic stocks have in two lots been screened of their resistance to helminthosporium during 1947—1960. A third lot of 340 types from the genetic stocks of 111—125 days duration were taken up for tests during 1961. One hundred and forty three types were found to be susceptible under artificial infection in the seedling stage. The remaining 197 types are being carried forward for further tests.

(b) *Testing of improved varieties and other experimental materials.*—The following materials were tested under artificial infection:

(i) *Wild and related species.*—Nine wild and related types of rice were tested under artificial infection. All the types remained free from infection.

(ii) *Chromosome Variants and tetraploids.*—The tetraploid mutants of the following varieties and the corresponding diploids were tested under artificial infection.

GEB. 24, Seta Tet. Sp. 1, Seta Tet. Sp 2, Seta Tet. Sp 3, Seta Tet. Sp 5, SR. 26 B, Indrasail Tet. Sp. 1, Indrasail Tet. Sp. 2, Indrasail Tet. Sp. 3, and Tet. 37.

It was seen that the tetraploids in general were more resistant than the corresponding diploids.

(iii) *Baok* × *Bonter selections.*—Nine cultures under F_5 were tested under artificial infection of which five were found to be susceptible.

(iv) *C. R. R. I. types.*—C.R.1-6 were tested under artificial infection, of which CR 1-5 were found to be susceptible.

(v) *Jeypore collections.*—Five types (extracts, of *fatua* and cultivated types) from the Jeypore Botanical Survey collections were tested under artificial infection of which four varieties were found to be susceptible.

(vi) *Non-lodging strains.*—Nine non-lodging strains were tested against Helminthosporium under artificial infection, out of which four strains were found to be susceptible

Varieties behaved as resistants in the above trials will be tested again in the next year.

2. *Breeding resistant Varieties by hybridization :*

As reported under the section of Botany, F_6 progenies of crosses between BAM. 10 (resistant to helminthosporium but susceptible to blast) and Co. 25 (susceptible to helminthosporium and resistant to blast) were studied during the year under review. Eleven field selections were made on the basis of number of fertile tillers and resistance to both the diseases.

3. *Studies on the nature of disease resistance of rice varieties :*

(a) *Effect of addition of nutrients to leached soil on the incidence of the disease.*—A severe incidence of helminthosporium is usually noticed towards flowering season in rice, growing in heavy monsoon areas. This study has been taken up to see whether such severe outbreaks could be checked by the supply of suitable nutrients before flowering of the varieties.

The experiment was started in the year 1959. Two early varieties *viz.* CH. 13 and Benibhog and two late duration varieties BAM. 10 and Latisail were used with the following treatments:

T_1—Control (no leaching—no manuring).

T_2—Basal manuring—no leaching.

T_3—Basal manuring—leaching—no remanuring.

T_4—Basal manuring—leaching—only Ammonium Sulphate added.

T_5—Basal manuring—leaching—only Ammonium Sulphate and Superphosphate added.

T_6—Basal manuring—leaching—only Superphosphate and Potash added.

T_7—Basal manuring—leaching—NPK added.

Fertilizers applied were as follows :—

1. Basal manuring—combination of NPK.

(Ammonium sulphate . . . . . 5.0 gms.
Super-phosphate . . . . . 3.2 gms.
Potash . . . . . 1.0 gm.
per pot containing 20 kg soil).

2. *Application of fertilizers after leaching.*—Half of the above dosage of N, P, K in different combinations as above.

It was observed that in general in early duration varieties the infection was highest in the treatment where Ammonium sulphate was added after leaching. The intensity of infection was less when P alone or P and K were added along with Ammonium sulphate.

In the late duration varieties the addition of normal dose of fertilizer to the soil increased the infection to a certain extent ; after leaching the soil, addition of Ammonium Sulphate or P_2O_5+K_2O or NPK, were all associated with higher infection, the addition of P_2O_5 with N however brought down the infection in the susceptible variety Latisail.

In the resistant variety BAM 10, addition of N or NPK after leaching brought down the infection.

(b) *Effect of Potassium.*—An experiment was carried out to study the role of Potassium nutrition on host susceptibility to *H. Oryzae*. T. 141 a variety resistant to helminthosporiose was used. The plants were grown under three levels of K, in culture solution *viz.*, (1) K-O, (2) K-6 ppm and (3) K-30 ppm. Observations were recorded on the incidence of disease at the time of flowering, the infection was highest in the treatment where K was not supplied in the nutrient solution.

III. *Blast disease*

A. *Breeding for disease resistance :*

(i) *Isolation of resistant varieties : Short duration types.*—The following 12 varieties have been finally selected as resistant to blast out of 497 Short duration types available in the genetic stock collection.

Accesion numbers :

27	..	2082	2597
28	1613	2250	
71	1771	2489	
533	1966	2565	

(ii) *Breeding resistant varieties by hybridization.*—As reported earlier in the section of Botany cultures from F_7 to F_{11} progenies of crosses between Co. 25—a long duration variety resistant to blast and Co. 13 a short duration variety highly susceptible to blast, were studied. Two hundred and ninety six field selections were made on the basis of their resistance, earliness and number of fertile tillers.

B . *Control of blast by fungicides :*

(a) *Efficacy of low volume spraying with organomercurial fungicide—Aretan.*—This experiment was carried out for the second year to confirm the earlier findings regarding the efficacy of low volume spraying with organomercurials in controlling blast disease of rice.

The variety Co. 13 susceptible to blast was used. The crop was transplanted on 19-8-61. The lay out of the field was a split plot with the varieties at the main split. In addition to about 20 lb N/acre supplied as green manure at puddling, 40 lb N/acre was given as Ammonium sulphate one month after transplanting.

The spraying treatments were (*i*) low volume spray at 20 gallons/acres (*ii*) normal volume spray at 100 gallons/acre and (*iii*) control. Aretan was used at a concentration of 0·195 lb/Hg. per acre under normal volume of 100 gallons; the same solution was applied in the low volume treatment also. Two spray applications were given once before flowering and the other after flowering. There was no leaf infection at tillering stage or neck infection at the time of harvesting.

The yield obtained with three treatments were as follows :

TABLE XXXVI

The yield in Kg/Ha of Co. 13 *under low volume* (20 *gallons/acre*) *and normal volume* (100 *gallons/acre*) *spray with Aretan* (0·195 *lb Hg/acre*)

Normal volume spraying (100 gallons/acre)	Low volume spraying (20 gallons/acre)	Control (unsprayed)
902	1005	899

It might be seen from the data given in the table above that the yield was highest under low volume spraying though the difference between the treatments were not significant.

(b) *Effect of spraying by fungicides-I.*—Recently it was reported that antibiotics were being used in Japan for the control of blast disease in the field. Antimycin A (@ 100 ppm) and Blastimycin (@ 10 ppm) were obtained from Japan. The antibiotic broth obtained from growing the Actinomycete, at Cuttack was also tried along with above two Japanese antibiotics. A fungicide (mercurised copper oxychloride) was also included (@ 0·6 lb/acre) to test the efficacy of the antibiotics as compared to the fungicide.

There were five treatments, *viz.*, 3 antibiotics, one fungicide and the control. The experiment was laid out as a simple randomised block with 8 replications, each unit plot being 29′×9·75′.

Co.13, a short duration susceptible variety was grown. The seed bed was sown on 17-7-61 and one month old seedlings were transplanted on 16-8-61. Green manure to give 20 lb N/acre was puddled in before transplanting. Ammonium Sulphate at the rate of 40 lb N/acre was applied a month after transplanting. As there was no blast infection in the leaf at the post transplanting stage, only two spray applications were given, one before and another after flowering. The rate of application was 20 gallons per acre applied with low volume nozzles.

There was no neck infection even in the unsprayed control plants at the time of harvest. The yield data obtained under different treatments are given below in Table XXXVII.

TABLE XXXVII

Yield (Kg/Ha) obtained with antibiotics and mercurised copper oxychloride sprays on Co. 13

Antimycin A	Blastimycin	C.R.R.I. Antibiotic	Mercurised copper oxychloride	Control
553·3	591·4	496·2	472·6	581·3

It might be seen that the plots treated with Blastimycin has given a little higher yield over the control but the differences between the treatments were not significant.

(c) *Effect of different fungicides-II.*—Orthophaltan, coppesan and C.R.R.I. antibiotic were used to test the efficacy of Orthophaltan and C.R.R.I. antibiotics in comparison to the control (unsprayed) and the copper fungicide coppesan. The experiment was laid out as a simple randomised block with 9 replications, each unit plot being 14′3″×9′6″.

Co. 13, a short duration susceptible variety was grown. About 39 days old seedlings were transplanted on 25-8-61. Green manure to give 20 lb N/acre was puddled in before planting. Ammonium sulphate @ 40 lb N/acre was applied a month after transplanting.

As there was no blast infection in the leaf at the post transplanting stage or at flower emergence stage only two spray applications, one on 7-10-61 and another on 16-10-61 were given @ 20 gallons per acre using low volume nozzles. The fungicides were used in the following concentrations :

Orthophaltan . . . . . @ 1 oz. in 3·5 gallons of water.

Coppesan . . . . . @ 2·8 oz. in 3·5 gallons of water.

C. R. R. I. antibiotic . . . 0·2 P.P.M.

The yield data obtained under different treatments are given below in ble XXXVIII.

TABLE XXXVIII

Yield (Kg/Ha) obtained with antibiotics & other fungicides

Orthophaltan	Coppesan	C.R.R.I. antibiotic	Control
508·1	486·5	486·5	490·1

In the absence of blast the relative efficacy of the treatments in controlling the disease could not be determined.

C. *Studies on blast disease forecasting :*

As in the previous years the susceptible variety Co. 13 was planted at four different dates, *viz.*, 7th, 14th, 24th and 31st August during the main crop season. There was no incidence of either leaf or neck infection in any of the above plantings. The slides exposed in the field since the beginning of flowering did not show presence of conidia of *Piricularia oryzae*, causal organism of the blast disease of rice.

D. *Soil microbiological studies with bacterial inoculant :*

This experiment was carried out as in 1961, with 'Azotobacterin' a bacterial inoculant obtained from U.S.S.R. (Through I.A.R.I.), to see its effect on the growth and yield of rice raised from seeds treated with the bacterial inculant. Seeds of PTB. 10 a short duration variety were soaked in 'Azotobacterin' in water and were sown in pots of 14" diameter@ three seeds per pot. Untreated seeds were sown as control. Ammonium sulphate, superphosphate and potash were added in different combinations. The number of fertile tillers, maximum height of the plant and weight of grain were recorded. There was not much difference between different treatments though in the previous year there was increase in yield in pots where the plants were raised from the seeds treated with 'Azotobacterin'.

E. *Seed treatment trials with antibiotics by presoaking :*

Seed treatment trials with antibiotics by presoaking were made for the control of helminthosporiose of rice. Two antibiotics, Griseofulvin and Nystatin, were used at the concentrations of 10,50 and 100 ug/ml. Seeds of two susceptible varieties, Co. 13 and T. 412, were soaked in the above dilutions for 72 hours at 32°C, germinated and sown. Plants were infected with spore suspension of *H. Oryzae* twice, once at the seedling stage and again at the time of flowering.

Results showed that helminthosporium disease was effectively controlled not only at the seedling stage, but also at the flowering stage of the plants. The antifungal properties of both Griseofulvin and Nystatin or the effect they induced at germination appeared to be retained within the physiological system of rice plants till maturity.

F. *New Diseases and Fungi :*

False smut disease caused by *Ustilaginoidea virens* Cke and Takahashi was reported on certain wild species of *Oryza* viz., *O. alta*,*O. perennis* (awned) cambodia, *O. cubensis* A, *O. Cubensis* B, *O. australiensis*, *O. spontanea* (Guinea), *O. spontanea* (Burma), *O. spontanea* (C.R.R.I.), *O. punctata*, *O. perennis* Var. balunga, *O. perennis* var barthii, and *O. grandiglumis*.

Physiology

I. *Root growth and Root elongation studies*

A technique for stydying the effect of various growth regulators on the growth and elongation of the roots was developed. Rice grains (variety PTB10.) soaked for 24 hrs. in distilled water are placed vertically in small holes on a filter paper fitted on the top of the beaker and kept constantly wet with water. After the radicles had grown 10-15 m.m. long, seedlings with uniform and straight radicles are measured and transferred to test solutions. Percentages of increase over the average initial lengths of radicles at the end of 72 hrs. of growth in test solution are compared with that in control (distilled water) Table XXXIX contains the observations made with certain chemicals.

Table XXXIX

Root growth and Root elongation studies

(% increase of root length after 72 hours of growth)

Growth regulators	0 ppm	0·1 ppm	1 ppm	10 ppm	100 ppm
Vitamin C . . .	466	498	593	522	..
Vitamin B_6 . . .	377	..	356	446	305
Nicotinic acid . . .	466	565	528	465	..
EDTA	623	619	615	710	..
Manganese sulphate . .	621	..	723	664	602

From the data in Table XXXIX it is obvious that Vitamin C., Nicotinic acid, EDTA and Manganese sulphate have pronounced promoting effect on root growth at certain concentrations. It was also found that all amino acids have distinct inhibitory effect on root growth. It will be interesting to determine, if prior to transplantation, roots of the seedling could be treated with any of the substances promoting root growth, in order to facilitate ready establishment and tillering.

II. *Study of Drought resistance in Rice*

(a) *Morphological and physiological characters of recommended drought resistant varieties* :

Ten varieties were dry sown and grown to maturity during the second season, under periodical drought condition. There were four replications and six lines per variety. The germination and growth were very poor and the plants were much affected by Helminthosporium. The following observations were recorded.

(a) Yield, (b) absorption-Transpiration ratio, (c) Stomatal frequency of lower and upper epidermis of leaves and (d) chlorophyll stability index at 65°C ± 1°C. The data are presented in Table XL.

Determination of chlorophyll stability index.—The original technique had to be modified for the peculiar nature of the experimental material and the modified form is presented below:

One gram of fresh green leaf, soaked in 25cc. of water and heated in a water bath maintained at 65°C ± 1°C for one hour, is extracted with 40 cc. of 80% acetone in a waring-blender for 5 minutes. The extract is filtered through No.1 filter paper and calorimetric (Klett Photo electric) reading of the filtrate is taken using No. 66 red filter. Similar reading from an unheated sample is taken as control. The difference between the two readings is 'Chlorophyll stability index' (hereafter referred to as C. S. I.).

TABLE XL

Drought resistance preliminary observations

Sl. No.	Variety	Yield in Kgm/Hec.	Absorption	No. stomata per focus		C.S.I.
			Transpiration	Lower	Upper	
1	W. 454 . . .	224·2	1·0370	24·44	24·52	12
2	W. 418 . .	276·6	0·9330	19·76	20·00	6
3	W. 703 . . .	680·1	1·1090	20·44	20·84	11
4	W. 794	40·4	1·0570	25·84	22·36	6
5	W. 691 . . .	433·8	1·0840	23·80	17·40	11
6	B. 76-116 . . .	330·0	1·0365	24·36	20·44	21
7	W. 745 . . .	218·7	1·0890	23·32	19·12	2
8	W. 371 . . .	824·3	1·0115	22·80	25·40	4
9	W. 398 . . .	371·3	1·0715	..	..	10
10	Ac. 511 . . .	295·9	1·0495	..	..	9

From Table XL it is obvious that the yield data are not dependable due to excessive damage by Helminthosporium. The ratio of absorption to transpiration is almost a unity, which is known to be true with all the mesophytes. Major varietal differences were obtained in the number of stomata in the upper and lower epidermis and also in regard to C. S. I. Further experiment is required to determine if these differences are correlated with the drought resisting capacity of the varieties.

(b) *Varietal trial under rainfed condition :*

For yield trial in the main season, the varieties Pla 1 and TKM. 1 were substituted for W.454 and W.794 used in the second crop reported above. It was later observed that TKM. 1 behaved as a medium duration type and could not be compared with the other nine varieties, which were earlier in duration. Therefore, in the yield data, as presented in Table XLI, TKM. 1 has not been included.

TABLE XLI

Drought Resistant varietal trial (yield of grain) 1961 *Main season*

Sl. No.	Variety	Yield of grain		% of control
		Kgm/ Hec	Lbs./ acre	
1	W. 745 (MTU. 17)	2728	2435	130·9
2	W. 418	2615	2335	125·5
3	W. 371	2598	2320	124·7
4	W. 691	2551	2278	122·5
5	B. 76-116	2083	1860	100·0
6	Ac. 511	1780	1589	85·4
7	PLA. 1	1728	1543	83·0
8	W. 703	1621	1447	77·8
9	W. 398	1358	1213	65·2
	C.D. 0·05	558	498	
	C.D. 0·01	756	675	

The data indicate that W. 745 (MTU.17) topped the performance and was at par with the varieties, W.418, W.371 and W.691. It is interesting to note that the recommended upland variety B.76-116 did not compare favourably with the varieties mentioned above. Another point of interest is that the stability of chlorophyll of all these varieties are consistantly lower than others in the Table (Table XL), MTU.17 (W.745) indicating the highest stability (*i.e.* lowest C.S.1.)

(c) *Physiological studies of Drought resistance in pot culture :*

This experiment was conducted during the main crop season. Two varieties of about the same duration one typically wet land type, Co.13 and the other a recommended drought resistant variety, MTU.17 (W.745) were dry sown, and grown to maturity under the following different treatments.

Treatment 1(T_1)=Two cycles of permanent wilting by artificial soil drought during tillering stage.

Treatment 2 (T_2)=The same at flowering stage.

Treatment 3 (T_3)=The same at milk stage.

Treatment 4 (T_4)=The same at all the above three stages.

Treatment 5 (T_5)=Normal watering throughout (control).

There were 5 replications per treatment each consisting of a pot containing 4 plants. Samples immediately after various treatments were taken for chemical analysis. The C. S. I. of the two varieties were taken at two different stages of the life cycle. The data are presented in table XLII.

TABLE XLII

The effect of drought on the yield and tillering in Rice

	Yield in gms. per pot		Yield as % over control		EBT at harvest		% of sterility		C.S.I.	
	MTU. 17	Co. 13	MTU. 17	Co. 13	MTU. 17	Co. 13	MTU. 17	Co. 13	MTU. 17	Co. 13
T_1 . .	19·15	13·14	130·0	51·7	21·8	12·0	10·02	34·04		
T_2 . .	12·74	8·08	86·5	31·8	20·7	11·0	21·94	54·50		
T_3 . .	11·09	14·75	75·3	58·0	19·7	13·8	28·90	28·50		
T_4 . .	8·80	4·42	59·8	17·4	23·6	12·0	26·31	75·81		
T_5 . .	14·72	25·43	100·0	100·0	17·4	12·8	11·84	14·46	0	10

C. D. for var. not significant.

C.D. for treatments=3·57.

T_1=Two cycles of permanent wilting at tillering.

T_2=Two cycles of permanent wilting at flowering.

T_3=Two cycles of permanent at milk stage.

T_4=Two cycles of permanent all above 3 stage.

T_5=Control with adequate soil moisture.

It is obvious from the data that both the varieties were affected by drought treatment but not in the same way and with the same degree. It may be noted that MTU. 17 was benefitted by the drought treatment at tillering, so much so that its yield was 30% higher than the control. It can be attributed to the fact that with the drought treatment followed by "restitution", the metabolic processes in this variety were much stimulated and heavy tillering was initiated. The degree of reduction in yield as well as percentages of sterility due to drought treatments at other stages was significantly less in MTU. 17 than the corresponding values for Co. 13. This makes MTU. 17, a truly drought resistant variety, genotypically and, as a result, physiologically. It is also interesting to note that the variety MTU. 17 consistently records a lower C. S. I. than Co. 13.

Preliminary data obtained from chemical analysis of samples also indicate great difference in nitrogen uptake and utilisation between the two varieties in response to drought treatment. Further work is in progress.

III. *Upland varietal trial*

This was a repetition of last year's trial. There were 14 varieties dry sown in four replications and grown under rainfed conditions. Results are presented in Table XLIII.

TABLE XLIII

Upland varietal trial (1961 *main season*)

Sl. No.	Variety	Yield of grain		% of control
		Kgms./ Hec.	Lbs./ acre	
1	Ac. 486	2659	2375	130·4
2	PTB. 10	2231	1992	109·4
3	W. 742	2213	1976	108·5
4	B. 76-116	2039	1821	100·0
5	Ac. 3902	1937	1730	95·0
6	Ac. 4	1877	1676	92·0
7	W. 999	1766	1577	86·6
8	W. 503	1637	1462	80·3
9	T. 657	1598	1427	78·4
10	JBS. 771	1565	1397	76·7
11	JBS. 598	1544	1379	75·7
12	CH. 45	1514	1352	74·2
13	JBS. 782	1328	1186	65·1
14	JBS. 1009	838	748	41·1
	C.D. (0·05)	259	231	

The yield data indicate that the variety Ac.486 topped the list and performed singificantly better than any other variety. This was closely followed in descending order, by Ptb. 10, W. 742, B.76-116, which were at par with each other.

IV. *Effect of foliar spray of Vitamin C on yield of rice*

Unlike last year, when a late variety (T.90) was used, this year two varieties—one of medium duration, T. 141, and the other early duration, N. 136 were used in this experiment. There were three treatments:

(a) Control.

(b) Seed soaked in 10 ppm Vit. C solution.

(c) Same as (b) plus periodic foliar spray with the same concentration of Vit. C at weekly intervals.

Results are presented in Table XLIV.

TABLE XLIV

Effect of Vitamin C on rice

(Average of 7 pots)

Treatments	Early variety N. 136		Medium variety T. 141	
	Grain wt/pot	% control	Grain wt/pot	% of control
Control	23·69	100·00	43·74	100·00
Vit. C soaked	13·91	58·72	49·09	112·23
Vit. C soaked & sprayed . . .	15·44	65·17	47·28	108·09

Results indicate that foliar spray of Vitamin C had a deliterious effect on the yield of N. 136. The effect of the treatments on the yield of T.141 was favourable although not significantly so.

These observations become more important in view of the fact that similar foliar spray of Vitamin C significantly promoted the yield of long duration type, T.90 last year. It would appear that the effectiveness of foliar spray of Vitamin C is some what related to the duration of the variety. Further experiment is required to substantiate this observation.

V. *Role of boot-leaf on grain setting and grain maturation of rice*

In this experiment the primary tiller and one secondary tiller of each plant were labelled and following treatments were given :

Control — Boot-leaf intact.
T_1 — Boot-leaf excised at ear emergence.
T_2 — Boot-leaf excised 10 days after ear emergence (milk stage).

There were four pots per treatment each with four plants. Appropriate samples were taken for carbohydrate analysis of grains. Data are presented in table XLV.

TABLE XLV

Role of Boot-leaf in grain setting

	Yeild in gms. per pot	
	Primary tiller	Secondary tiller
Control	11·55	7·80
Treatment T_1	10·35	6·19
Treatment T_2	9·40	6·59

Percentage of acid hydrolysable carbohydrates on dry wt. basis

Stage of samp ing ..	Contro	T_1	T_2
At flowering	28·65	28·65	28·65
10 days after flowering	43·12	53·85	43·12
20 days afte flowering	43·88	35·11	45·16
30 days after flowering	45·91	43·53	45·93

T_1 = Boot leaf cut at ear emergence.
T_2 = Boot leaf cut at 10 days after ear emergence.

The data indicate that boot leaf contributes some factor or factors, which affect the yield of grain in the panicle concerned. The chemical analysis shows, however, that the final acid-hydrolysable carbohydrate composition of grains remains almost the same irrespective of the treatments, although some fluctuation in this respect was found to take place in the treatment T_1 before the harvest stage was arrived. Further research is required to determine if other functional leaves contribute in the process of grain maturation, when boot leaf is excised and, if so, to what degree.

VI. *Nutrition studies*

(a) *Use of an organic phosphate as a source of phosphorus for rice plants in nutrient culture :*

In this experiment ethyl Ammonium Phosphate, an organic phosphate received from the Monsanto Chemical Company, U.S.A., was tested as a source of phosphorus for rice plants in nutrient culture. It was compared with two inorganic phosphates, namely, potassium dihydrogen phosphate and sodium dihydrogen phosphate. The concentration of phosphorus for all three sources was 20 ppm. as P_2O_5. The additional nitrogen in the form of ammonium group in Ethyl Ammonium Phosphate (hereafter referred to as EAP) was compensated for in the other two treatments. There were seven replications per treatment, each consisting of a 4-litre glazed porcelain pot with two plants in it. The variety used was Ptb. 10. Harvest data are presented in Table XLVI.

TABLE XLVI

The effect of organic Phosphate on rice in water culture

Source of phosphorus	Ht. in cms.	Comparative Harvest Data			1000 grains wt. in gms.
		No. of ear-bearing tillers /pot	Yield in gms/pot	%of sterility	
Potassium di-hydrogen phosphate	127·8	18·57	25·81	11·54	26·68
Sodium di-hydrogen phosphate .	129·4	18·86	27·36	10·08	27·01
Ethyl ammonium phosphate .	125·3	19·80	27·53	9·50	28·14

Percentage of Phosphorus in terms of dry wt.

Parts of the plant	Days from sowing	Potassium di-hydrogen phosphate	Sodium di-hydrogen phosphate	Ethyl ammonium phosphate
Shoot	40	0·52	0·54	0·51
	60	0·40	0·39	0·38
	70	0·32	0·30	0·26
	110	0·1375	0·1015	0·085
Root	40	0·47	0·41	0·33
	60	0·265	0·211	0·203
	70	0·190	0·150	0·150
	110	0·096	0·0815	0·064
	70	0·32	0·295	0·300
Young panicle mature grain	110	0·367	0·3245	0·328

It will be evident from the table above that EAP was at par with the other two sources of Phosphorus as far as yield was concerned. This organic source of phosphorus does not dissociate in solution and, therefore, this can be used even at unfavourable pH levels when the availability of P from inorganic sources becomes uncertain. Chemical analysis of plant parts indicate that plants receiving EAP absorbed the least amount of P except at reproductive phase. Since this reduced uptake did not affect the yield it may suggest that P of EAP is very efficiently utilised by rice plants. Further research is in progress.

(b) *Studies on Optimum Fe (Iron) requirement of rice plants :*

Since iron plays an important role in combination with phosphorus and other elements in the overall growth of plants an experiment was designed to determine optimum requirement of iron for rice plants growing in water culture. There were six treatments with four replications each consisting of a 3·5 litre glazed porcelain pot with two plants in it. Source of Iron was 'Versenol', iron chelate received from Dow Chemical Co., U.S.A. Concentrations of Fe used were 0,1,2,3,4 and 5 ppm. Table XLVII given below contains the average yield data.

TABLE XLVII

Effect of different doses of Fe on plant growth and yield

Sl. No.	Fe conc. treatment	Grain yield in gms/ pot	% of control
1	0 ppm	21·89	100·00
2	1 ppm	24·25	110·8
3	2 ppm	24·55	112·2
4	3 ppm	29·23	133·5
5	4 ppm	25·00	114·2
6	5 ppm	23·15	105·8

C. D. not significant.

The statistical analysis does not indicate any overall significance of treatments but there is a significant indication of 3 ppm Fe being the optimum concentration for rice plants. The experiment is being repeated with suitable modification and demineralised water is being used to eliminate the possibility of Fe-contamination of the nutrient solutions.

Blue-Green Algae

It has now been accepted that Nitrogen fixing Myxophyceae appear to be of great importance in contributing to the fertility of certain habitats, tropical soils in particular.

With this view a scheme has been taken up at the Central Rice Research Institute, Cuttack on "Nitrogen fixation by Blue-green Algae in Rice fields". The scheme came into operation only after the Assistant Chemist joined this year.

The objective of this scheme is to examine the possibilities of increasing the yield of rice by inoculating Myxophyceae in the rice fields and investigations of the fundamental aspects of nitrogen-fixaon by blue-green algae, their behaviour under different ecological conditions in rice soils and to find out how far it can help in fertilizer economy.

With this view the following experiments have been initiated.

I. *Collection of algae from rice fields of the Central Rice Research Institute*

Algae have been collected every month during the year under report from the premises of Central Rice Research Institute. It has been preserved in a preservative containing formalin, acetic acid, alcohol, glycerine and water. The amount of ingredients have been adjusted to suit the algae collected. It is proving satisfactory.

II. *Identification of algae collected*

The following members of algae have been identified as per classification given below :

(a)	Class	Chlorophyceae (Isokontae)
	Order	Conjugales
		Euconjugatae
		Zygnemoideae
		Zygnemaceae
		Genus—Spirogyra sp.
(b)	Class	Myxophyceae
	Order	Nostocales
		Nostocaceae
		Genus—Nostoc. sp.

III. *Development of the technique of drying and culturing of algae*

Because of the peculiar constitution of some of the algae its drying presents some problem. Technique has been worked out and sun dried inoculum of algae is now being tried in pot culture experiment on the investigation of effect of algae on rice.

IV. *Study of the effect of algae on rice in relation to chemical nutrients*

Study of the effect of algae on rice is under progress in potted plants and under field conditions. Ptb. 10 variety of rice is being used.

(a) *Pot culture experiment :*

The plan of layout consists of eighteen treatments with five replications in a Randomised Block design. The details of treatments are given below :

Treatments—

A—Ammonium sulphate at the rate of 16·8 kg./hectare.
B—Ammonium sulphate at the rate of 33·6 kg./hectare.
C—Superphosphate at the rate of 67·2 kg./hectare.
D—Superphosphate at the rate of 67·2 kg./hectare+Sodium. molybdate at the rate of 0·28 kg./hectare.
E—Lime at the rate of 2242 kg./hectare.
F—Lime at the rate of 2242 kg/hectare +Sodium. molybdate at the rate of 0·28 kg./hectare.
G—Superphosphate at the rate of 67·2 kg./hectare +Lime at the rate of 2242 kg./hectare+Sodium molybdate at the rate of 0·28 kg./hectare.
H—Sodium molybdate at the rate of 0·28 kg./hectare.
I—Control (only soil without any chemical nutrients).
J—A +algae.
K—B+algae.
L—C+algae.
M—D+algae.
N—E+algae.
O—F+algae.
P—G+algae.
Q—H+algae.
R—I+algae.

The pots were inoculated with algae collected from Central Rice Research Institute. Observations on the growth of algae and paddy plants were recorded. In the initial stage there was a vigorous development of green algal forms in pots with treatments J and K where ammonium sulphate and algae were added. In these pots the green mass practically choked the growth of paddy seedlings. Other treatments did not reveal pronounced trends in the growth of algae. Further investigations on growth of paddy seedlings and development of algae in the pots are in progress.

(b) *Field experiment :*

The above experiment is also being initiated in the field.

Paddy nursery with variety Ptb. 10 has been raised for the above experiment.

V. *Lectures and training to National Training Course*

Lecture on "Algae and its utilisation with special reference to Cyanophyceal" has been delivered to National Training Course. Practicals on algae have also been conducted.

VI. *Advice and materiol given to outside workers*

(a) Rice and Wheat Specialist, Nawagam, Gujarat State, has been advised regarding supply of Blue-green Algae. He has also been informed that among the members of Myxophyceae; Anabaena, Nostoc, Tolypothrix are good nitrogen fixers and that one or more of these may be tried.

(b) Preserved specimens of Blue-green algae have been given to Dr. G.S. Venkataraman, Indian Agricultural Research Institute, New Delhi on his personal request.

Statistics

Detailed Technical report for the calendar year 1961

In addition to rendering assistance to various research divisions in designing experiments, statistical analysis of data and interpretation of the results, the division carried out the following items of work.

1. *Field trial :*

The experiment to study the competition effect of varieties due to positions was laid out this year also. The number of varieties, the total number of treatments, size of the plot remained same as last year. The system of planting was as follows :—

(1) The varieties planted as such (control),

(2) A variety followed by another in alternate rows, and

(3) A variety followed by another after every third row.

As the crop is just harvested and the analysis of the data is in progress, the results for this year could not be incorporated in this report. However, the results for 1960 are presented in Table XLVIII.

Table XLVIII

Mean yields in kg/ha

	Control	Followed in alternate rows by		Followed after every third row by		
		T.1242	GEB.24	T.412	T.1242	GEB.24	T. 412
T.141 . . .	3559	2880	2584	3174	2891	2355	2789
T.1242 . . .	2325	..	2126	2484	..	1776	2776
GEB.24 . . .	1193	..	..	2150	..	..	2295
T.412 . . .	3108	..	..	..	..	..	..

C. D. (0·05) for comparing the means—540.

It will be seen from the above table that T. 141 planted as such is superior most. Next in rank comes T. 412. None of the other combinations has yielded better than these.

In general, the alternate row planting does not appear to be superior to the other system of planting. The varieties T. 141 and T. 1242 seem to cooperate well with GEB. 24.

2. *Laboratory studies :*

(i) *Biometrical studies.*—Growth curves were fitted to the data on height, number of tillers per plant under the developmental studies for 1960-61. Curves of the type

(a) $Y=A(10)bx$

(b) $Y=a+bx+cx^2$

were found to fit well to the height and tillers respectively.

It was observed that the maximum tillers per plant would be obtained between 7 to 10 weeks of the growth of a plant.

Behaviour of the data on height, ear bearing tillers and flowering duration of F_2 with varying sterility was studied by fitting normal curves under normal and high fertility conditions. It was observed that height deviated more from normality than the other two characters with the increase in the percentage of sterility.

(ii) *Correlation studies.*—Simple correlation co-efficients were computed for yield and its attributes such as height, ear-bearing tillers, length of the panicle, number of normal grains and sterility percentage of the data pertaining to F_3 generation of the cross Zuiho×T. 141. It was observed that the height and length of the panicle showed maximum correlation (+0.4136) while the length of the panicle and single plant yield the least (+0.0294). Sterility percentage was found to be negatively correlated with other characters under study.

(iii) *Discriminant function studies.*—Discriminant functions were developed with yield and its attributes for the selection of plants in F_6 generation under normal and high fertility conditons. These are as follows :—

Normal Fertility $D=5y-7x_1-3x_2+29x_3+x_4$

High Fertility $D=80y-213x_1-7x_2+115x_3+x_4$

where y=the single plant yield, x_1=no. of ear-bearing tillers, x_2=the height of the plant in cm., x_3=length of the panicle in cm., x_4=mean number of normal grain per panicl.

(iv) An attempt was made to study the plot to plot variation in experiments where the same crop was grown continuously over a period of years. It was observed that, in general, the plot to plot variation did not go beyond ten per cent of the general mean of that crop.

3. *Training :*

Theoretical and practical classes in statistics were held for the trainees under the National Training Course for Rice Breeders and Technicians, 1961. In addition to the above, a similar course was also conducted for the post-graduate students of Utkal Krishi Mahabidyalaya, Bhubaneswar.

Farm

An area of about 12 acres was directly sown with paddy and about 43 acres with green manures as *dhanicha* and *Sesabania speciosa*. Heavy rains during the first half of June caused water stagnation in the fields which resulted in the poor germination of the seeds. Hence a few seed beds had to be resown. A total area of about 45 acres was under the experiments of the different divisions and the area under seed multiplication was about 75 acres.

An area of 5 acres was raised under paddy seedlings and these were supplied to the cultivators in the flood affected areas realising an amount of about Rs. 800.

As a result of the floods, the medium and late duration varieties suffered miserably and yields were as low as 12 maunds per acre during the year, as against 20 to 25 maunds obtained during the previous years. There was unsetting of the grains to a great degree.

The following experiments were conducted during the year.

1. *Maximum Potential Experiments :*

The block of 4·97 acres allotted for this experiment was sown with *dhanicha* @ 40 lbs per acre by May 15th after a subsurface application of Superphosphate @ 150 lbs per acre. The untimely rains in June submerged the very young plants and mortality was found to be quite heavy. As the production of green manure was not satisfactory, 4000 lbs. *gliricidia maculata* loppings were applied in each acre of land and the plots puddled. 50 lbs. Ammonium Sulphate was applied to these plots per acre before the final puddling, and seedlings of the popular strain T. 1242 were planted by the first week of August.

The heavy rains during the 1st week of September submerged the crop to a depth of about 3 to 4 feet and by the time the water receded, it was found that the whole crop had perished. The plots were brought to condition by the 3rd week of September and seedlings of J. 192 were planted even though they were about 2 months old, to avoid leaving the whole block fallow.

An average yield of 13 maunds/acre was obtained from this block.

2. *Study of the economics of growing paddy by drilling, dibbling, broadcasting and transplanting :*

A proper assessment of the performances of each of these treatments could not be made due to the damage caused by the flood. However, it was noticed that there were more number of plants in the plots which were directly sown that in the transplanted ones, proving thereby that well established plants resist submergence to a great extent.

3. *Study of the effects of tractor ploughing in the low lying areas on the yield of transplanted rice :*

This experiment was also badly spoiled as a result of the flood leaving only a plant population ranging from 10 to 15% in these plots. Consequently no data could be collected.

4. *Studies on vegetative propagation :*

F_1 cultures of six cross combinations made with a view to evolve cultures possessing non-sensitivity and high yielding characters, were multiplied vegetatively from a single clump from January, 1961 onwards and finally planted in the main plots during August, 1961. The object in taking up this work was to produce maximum quantity of F_1 seed in one season for detailed studies. This method appears to be the best for the rapid multiplication of F_1 seed where there is high percentage of sterility. The number of plants produced from a single clump vegetatively and the area covered by the same on planting are given in Table XLIX.

TABLE XLIX

Sl. No.	Cross combination	No. of plants obtained from a single clump at the time of final planting	Area planted 12″×6″ singles (Ac.)
1	W. 114×GEB. 24	36,657	0·42
2	GEB. 24×G.S. 137	25,520	0·29
3	PTB. 10×W. 112	2,532	0·03
4	CH. 45×W. 135	17,888	0·20
5	W. 140×T. 412	61,080	0·70
6	JBS. 120×T. 141	17,482	0·20

The data in Table XLIX indicate clearly as to how the hybrid vigour present in the F_1s can be exploited to produce maximum number of plants by vegetative propagation for large scale field studies.

5. *Studies of the performances of the crosses (F_1) multiplied vegetatively when compared with the F_2 seedlings and the parents raised from seed :*

The following cross combinations multiplied vegetatively were tested against the F_2 seedlings and the parents raised from the seeds.

The different treatments were tested in randomised replicated trials. A thorough idea of the performances of each of these treatments could not be had due to the damage caused to the experimental strips by the flood. The data recorded are given in Table L.

TABLE L

Sl. No.	Cross combination P_1 P_2	Yield of grain in lb. per acre				Remarks
		P_1	P_2	F_1 from stubbles	F_2 seedling	
1	CH.45×W.136 . .	450	545	1105	336	
2	PTB.10×W.112 . .	700	512	769	665	
3	W.140×T.142 . .	705	465	2168	304	
4	T.141×W.141 . .	576	1297	3011	1410	
5	GEB.24×G. S. 137 .	Washed off during floods due to the force of the current				
6	Lama paddy×Ac. 2925					

Consequent on the complete submergence of these experimental plots for a period ranging from 5 to 9 days, there were many gaps in the plots planted with the seedlings raised from seeds. However, the data clearly indicate that the F_1s multiplied by vegetative propagation have been uniformly giving better performances than the rest of the treatments. The plants raised by vegetative propagation have uniformly resisted the floods and submergence.

This finding was also confirmed in a plot one half of which was planted with the seedlings of GEB.24 raised from seed and the other half by the seedlings of the same variety multiplied vegetatively. This field was also completely submerged for a period of 9 days and after the floods receded it was noticed that the plants raised by vegetative propagation remained intact, whereas more than 75% of the plants in the other treatment perished. At the time of harvest the stubble propagated plants were found to be absolutely erect even though the variety selected has a bad lodging character and this crop gave an yield of about 20 mds. grain per acre as against 5 mds per acre from the submerged plot. Studies in this line will be continued next year.

6. *Studies on the modified technique for rice culture :*

An experiment was laid out with two recommended strains T. 141 and Bam. 9 to establish the superiority of this method. The treatments were (1) Planting with a spacing of 12″ × 6″, (2) Planting with a spacing of 6″ × 4″ and (3) Planting with a spacing of 12″ × 6″ uprooting the plants in the strip after 30 days, splitting the bulk tillers into three and replanting them in the same area with a spacing of 6″ × 4″.

The experiment was badly spoiled due to the heavy floods.

Seed distribution :

A total quantity of 600 mds. seed in the different improved strains was supplied to the local Agricultural Department.

Agricultural Engineering

I. Research and Development

1. *Fundamental Research :*

A new line of research work was recently initiated to develope a technique to determine soil puddliability.

A simple penetrometer which enables application of force ranging from 1 to 9 per 25 cm^2 was used to determine the effective depth of puddle.

Duplicate 100 gm. of wet soil out of different soil samples from various spots were centrifuged at 2000 rpm. The degree of puddle was measured by noting the shrinkage in depth.

Using the above technique efficiency of different bullock drawn implements was tested.

2. *Land preparation implements :*

Field trials were conducted to investigate the performance of bullock drawn ploughs for paddy cultivation under wet land conditions. Orissa Duck foot plough gave a better performance with regard to output and quality of work for ploughing and puddling work. Mould board plough was effective in burying weed and grass. The Melur plough gave a satisfactory performance under optimum moisture conditions.

3. *Seeding and Transplanting Equipment :*

(i) Field trials were conducted to find out the efficacy of direct drilling of paddy seed in dry soil as compared to transplanting method.

On account of heavy rains and floods most of the crop under experiments was damaged and as such a reliable data could not be obtained.

(ii) The development of a seeder that will enable direct seeding of paddy in puddle has been undertaken. Preliminary investigations and fabrication of the components is in progress.

4. *Harvesting tools :*

(i) A simple Push type of Paddy Harvester has since been developed. Field trials are in progress to improve its performance. Attempts are being made to attach a Windrowing attachment to facilitate its cutting action and removal of the cut crop.

(ii) Two models of Push type Harvesters developed at the Allahabad Agricultural Institute were tested in collaboration with Mr. Yosbida, Professor of Japanese Farm Machinery. As a result of the observations made, further modifications were carried out to improve the design of cutting blades. Further work on these implements is in progress.

II. *Mechanisation of Rice cultivation*

(i) Field trials were carried out to study the scope of mechanisation on small holdings for wet land paddy cultivation with Power Tiller. Results obtained so far with one of the Tillers have been encouraging but in order to have a proper assessment it will be necessary to continue further trials with a variety of equipment.

(ii) The entire area of the farm is now being worked with mechanised equipment for Land preparation, threshing, transportation and post harvest cultivation. Field observations on different aspects of economy and performance are being conducted to obtain an up-to-date information under normal working conditions.

(iii) Attempts were made to fabricate parts of paddy Disc harrow which were not readily available.

(iv) Field experiments have been initiated to determine the Tillage requirements for paddy cultivation. Similarly, work has been started to find out the optimum requirements of puddling operations under wet land conditions.

Workshop :

(i) The upkeep and repair work on farm tractors, Agricultural machinery, hand tools, implement equipments and transport vehicle is being carried out in the workshop.

(ii) Fabrication and development of new tools and equipment is being undertaken.

(iii) Assistance is being given to other divisions regarding the installation upkeep and repair of equipment for research and field work.

TRAINING

Six Post-graudate students of Utkal Krushi Mahabidyalaya, Bhubaneswar specializing in rice Agronomy/Botany joined the Institute for doing the thesis part of the course and they worked on the following research problems.

Agronomy

B. B. Mandal . . .	Studies on the cultural and manurial requirements of some varieties of rice (*Oryza sativa* L.).
M. V. Rao . . .	Study of differential response of some medium duration varieties of rice (*Oryza sativa*) to increasing levels of nitrogen.

Botany

R. N. Panda . . .	Studies on the inheritance of hairiness in lemma-palea and leaf blade and liguleless condition and interrelationship of genes governing these and other morphological characters in rice (*O. sativa* L.).
S. K. Mohanty . .	Studies on rice dwarfs (*Oryza sativ* L.) and basis for their classification.
K. L. Hakim	Studies on crosses between wild and cultivated rices.
A. K. Richharia . .	Cytogenetical studies on tetraploid rices

The second National Training Course of rice technicians started on the 15th June, 1961. 15 trainees from 10 States in India attended the course which lasted for six months. During this period the trainees were given full information on the different aspects of rice including origin, history, botany of rice plants, cultural practices, plant protection measures, breeding procedures and seed multiplication. Practical classes were conducted in the different subjects. Experts from Foreign countries also delivered lectures to the trainees. The trainees were taken to research stations in West Bengal and Madras to acquaint themselves with the different breeding programmes in operation in the different experiment stations. The course terminated on 15th December, 1961.

PUBLICATIONS

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2. Vachhani, M. V., Upadhyaya, S. R. & Rao, M. V. (1961).—Influence of spacing on plant characters and yield of transplanted rice. *Rice News Teller* **9** : 2. : 15-16.
3. Vachhani, M. V., & Murty, K. S. (1961).—Intercropping of Broadcast paddy with *Dhaincha* for Green Manuring. *Rice News Teller* **9** : 1 : 19-20.
4. Vachhani, M. V. & Murty, K. S. (1961).—Possibility of application of Green Manures to Semi-dry Rice crop. *I. C. A. R. Seminar on Green Manuring, Bombay.*
5. Vachhani, M. V. & Murty K. S. (1961).—Fixation of suitable Green Manuring species for Rice crop grown in Kharif and Rabi seasons and under Water logged and Rainfed conditions. *I. C. A.* R. *Seminar on Greent Manuring, Bombay.*
6. Vachhani, M. V., & Murty, K. S. (1961).—Seed Production of Green Manuring crops for Rice Areas. *I. C. A. R. Seminar on Green Manuring, Bombay.*
7. Vachhani, M. V., & Chaudhry, M. S. (1961).—Present position of Research on Weed control in India. Recent Advances in Weedicides and Techniques with particular reference to Rice Crop and suggestions for Future work. *I.C.A.R. Seminar on Weed Control, Bombay.*
8. Vachhani, M. V. & Chaudhry, M.S. (1961).—Herbicides for weed control in Rice Fields. *I. R. C.*/P.P./61.
9. Vachhani, M. V., & Mahapatra, I. C. (1961).—Variety × Fertilizers Interaction, *I. R. C.*/Joint/61.

10. Richharia, R. H. (1961).—Maintenance of purity of seeds of rice varieties and their multiplications by the technique of vegetative propagagation. *Proc. I. R. C. 9th meeting of the working party on production and protection—New Delhi* 1961.

11. Richharia, R. H. & Balakrishna Rao, M. J. (1961).—Vegetative Propagation of rice and its potentiality. *Rice News Teller* **9** : (3) : 26-27.

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13. Richharia, R. H. & Govindaswami, S. (1961).—Reduction in the number of rice varieties and breeding of varieties with wide adaptability. *I. R. C. Meeting. Working party on Plant Production and Protection.* Item No. 7.

14. Richharia, R. H. & Govindaswami, S. (1961).—A note on the utilisation of genes of wild rices in evolving improved types of cultivated rices. *Rice News Teller* **9** : (4) : 1-6.

15. Richharia, R. H. & Govindaswami, S. (1961).—Possibility of selecting *indica* type cultures responsive to high fertilization as observed from the collection made from the Jeypore tract in Orissa. *I.R.C. Meeting. Working Party on Rice Production and Protection.* Item No. 5.

16. Richharia, R. H. & Seetharaman, R. (1961).—Variability in the Genetic Stock of Rice—Hulling percentage. *Proc. Bihar Acad. Agric. Sci.* 8 & 9, 98-109.

17. Richharia, R. H. & Seshu, D. V. (1961).—Cytogenetics of an interspecific hybrid in the genus, *Oryza*, L. *Curr. Sci.* **30** : (3) : 189.

18. Richharia, R. H. Sampath, S., & Seetharaman, R. (1961).—Use of irradiation in rice breeding—An approach to mutation breeding in Rice. *I. R. C. Meeting. Working Party on Rice Production and Protection.* Item No. 10.

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23. Sampath, S., and Seshu, D. V. (1961).—Genetics of photoperiod response in Rice. *India J. Genet. & Pl. Breed.* **21** : 38-42.

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35. Israel, P. & Seshagiri Rao, Y. (1961).—New pesticides for control of insects, diseases, weeds and other pests of paddy. *Ibid.*

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37. Padmanabhan, S. Y. (1961).—Use of vacuum for the control of helminthosporium disease. Paper presented to I. R. C. Working Party on rice Production and Protection, New Delhi.

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45. Chakrabarti, N. K. (1961).—Fungicides for control of Helminthosporium disease. *Ibid.*

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PROGRAMME OF WORK FOR THE YEAR 1962

Agronomy Division

1. Study of the yield performance of different duration varieties.
2. Trial of varieties for late aman planting and double cropping.
3. To determine the suitability of various crops for growing in rotation with rice.
4. Intensity of cropping and crop pattern investigations on rice crop.
5. Developmental studies.
6. Effect of seed treatment with bacterial culture on the yield of rice.
7. Study of the efficiency of various herbicides for control of weed in rice field and determining the optimum dosage and time of application.
8. Study of the relative efficiency of various nitrogenous fertilizers.
9. Determination of optimum dose, time and method of application of nitrogenous fertilizers and their residual and cumulative effect on soil fertility.
10. Response of different duration varieties to various spacings, manuring and their times of application.
11. Determination of cultural-*cum*-manurial requirements of rice.
12. Determination of critical period of water requirement of rice crop.
13. Effect of spray fertilisation with urea on rice crop.
14. Study on the cooking qualities of different rice varieties.
15. Commercial classification of rice.

Botany Division

I. Maintenance and study of Genetic stocks.

II. Improving yield by—

A. Selection—Secondary selection in basumati types.

B. Hybridization—

(i) Between *japonica* × *indica* varieties. Study of F_5, F_8 generations in progeny row trials and F_9, F_{10}, F_{11} and F_{12} generations in bulk trials.

(ii) Within *indica* group. Trial of fixed cultures at this Institute and in the different *japonica*×*indica* units in the States.

III. Breeding for disease resistance. :

(i) Breeding for blast resistance. Study of F_8, F_9, F_{10}, F_{11} and F_{12} generations in progeny row tirals and F_8, F_{10}, F_{11}, and F_{12} generations in bulk trials.

(ii) Breeding for blast-*cum*-helminthosporium resistance. Study of cultures in F_8 generation.

IV. Breeding for high yield combined with quality. Study of cultures in F_8, F_9 and F_{10} generations.

V. Breeding for profuse tillering habit. Study of cultures in F_6 and F_8 generations.

VI. Comparison of the different methods of breeding.

VII. Studies on hybrid vigour in rice and its utilization in rice improvement programme.

VIII. Breeding for high yield and low photosensitivity :

(i) Study of cultures in different generations.

(ii) Study on the reaction of *japonica indica* and *javanica* types.

IX. Breeding for high yield and non-lodging habit :

(i) Study of material in F_6, F_7 and F_8 generations.

(ii) Maintenance of types.

(iii) Comparative study of different attributes that influence lodging.

X. Genetical studies :

(i) Inheritance of hairiness, clustering habit, notched kernel and liguleless condition in rice.

(ii) Nature of anthocyanin pigmentation by paper chromatography.

(iii) Biometrical genetics. Study on the influence of sterility on the genetics of certain characters.

(iv) Linkage studies.

XI. Studies in *O. glaberrima*. Study on the inheritance of a few characters in inter-varietal crosses.

XII. Studies on irradiation. Genetics in irradiated material.

XIII. Laboratory studies :

(i) Study on the variability in Genetic Stock for hulling percentage and protein content.

(ii) Study on the cooking quality in rice varieties.

XIV. Cytogenetics:

(i) Study of chromosome variants.

(ii) Study of tetraploids.

(iii) Study on the inter-relationship of species in the genus.

(iv) Exploitation of useful genes from wild types.

(v) Maintenance of wild species.

(vi) Study on the differentiation in the species.

XV. Jeypore Botanical Survey. Maintenance of cultivated and wild types collected during the period of the scheme and their evaluation.

XVI. Central Saline Rice Research Sub-Station:

(i) Maintenance of saline resistant types.

(ii) Screening of varieties.

(iii) Secondary selection in established salt resistant types.

(iv) Breeding for salt resistant types.

(v) Study on the performance of green manure crops under saline conditions.

(vi) Estimation of loss due to hispa.

(vii) Response of saline resistant varieties to fertilizer response and yield.

XVII. Scheme for the evolution of *japonica* × *indica* hybrid varieties:

(i) Study of cultures in different generations.

(ii) Trial of *japonica* and Taiwan types.

(iii) Trial of fixed hybrids.

(iv) Developmental studies.

(v) Crossing programme.

Chemistry Division

I. Investigations on nutrient availability in water-logged soils:

1. Transformation of applied nitrogen in water-logged soils.
2. Phosphorus fixation and transformation in water-logged soils.
3. Effect of nitrogen application on the displacement of cations from the soil complex.

II. Investigation on nutrient assimilation by the rice plant:

1. Comparison of efficiency of phosphorus absorbed at different stages of growth of *indica* and *japonica* rice varieties for grain production.
2. Role of iron and manganese in the growth of rice plant.
3. Effect of antibiotics and vitamins on the plant growth.
4. Study of high fertilizer response in different rice varieties and its genetics.

5. (a) Growth and uptake of nutrient by rice varieties of different durations.

(b) Investigations connected with nutrient uptake in vegetatively propagated rice plants and its comparison with the plants raised normally from seed (*cf* 5a.).

III. Fertilizer-soil-water relationship in rice:

1. Utilization of applied nitrogen by rice plant in relation to level and time of application.

2. Paper chromatographic test to determine the nitrogen reserve in leaf tissue to know the need or otherwise of nitrogen top dressing.

IV. Studies on the physical properties of rice soil.

ENTOMOLOGY DIVISION

1. Studies on varietal reactions of rice gall fly and stem borers.

2. Insect resistance in rice with particular reference to gall fly and stem borers.

3. Efficacy of different methods of application of insecticides in controlling pests.

4. Estimation of loss due to *hispa* and *gundhi* bugs.

5. Studies on the influence of macro and micro-climatic factors on the seasonal prevalence and incidence of gall fly and stem borers.

6. Studies on incidence of pests in relation to cultural and agronomic practices.

7. Studies on nature of gall formation in rice.

8. Collection of indigenous parasites and predators and studies on biological control of pests.

9. Studies on the seasonal abundance of rice pests with a view to forecasting their out breaks.

10. Influence of manuring on the incidence of gall fly.

11. Relative efficacy of insecticides in the control of rice pests—field and laboratory investigations.

12. Fish-culture in rice fields.

13. Studies on nematodes in rice and rice soils.

MYCOLOGY DIVISION

I. Study and estimation of resistance to diseases in field of the collection of types under Genetic stocks.

II. Helminthosporium disease:

(i) Collection of isolates of *H. oryzae* from different parts of India and testing selected resistant varieties with a mixture of isolates. (Pot experiment).

(ii) Artificial infection tests on early and medium types of genetic stocks for selection of resistant types—pot experiment.

(iii) Breeding resistant varieties by hybridization (field)—(in collaboration with Botany Section).

(iv) Studies on the nature of disease resistance of rice varieties—laboratory study.

Effect of nutrition on disease expression—

(a) Effect of leaching of soil on incidence of disease.

(b) Effect of K nutrition on incidence of disease.

(c) Effect of chlorophyll and xanthophyll on growth of *H. oryzae*.

(v) Studies on collateral hosts—pot experiment and laboratory Study.

(vi) Co-ordinated trial of resistant varieties in different rice growing states and saline sub-station at Port Canning.

(vii) Multiplication of resistant types (field).

III. Blast disease :

A. Artificial infection tests in seedling stage—

(i) Artificial infection tests on early and medium types of genetic stocks for selection of resistant types (post Expt.)

(ii) Testing of short duration varieties under World Genetic Stocks (field and pot. Expt.).

(iii) Testing of varieties released from C.R.R.I. and other experimental materials.

(iv) Testing of varieties received from outside.

(v) Uniform blast nursery trial.

(vi) Testing of resistant types in Derras Farm and Nuapalli Village.

(vii) Coordinated trial of resistant varieties in different rice growing States and saline sub-station at Port Canning.

B. Breeding of resistant varieties by hybridization and selection (in collaboration with Botany section)—(Field Expt.).

C. Studies on collateral hosts (Pot Expt.).

D. Studies on nature of disease resistance of rice varieties—

(i) Resistance to penetration and development of infection—(laboratory).

(ii) Genetical studies on disease resistance in collabortion with Botany Section—pot culture.

E. Control of blast by spraying—

(i) With different fungicide (new formulations).

(ii) With antibiotics.

F. Studies on blast disease forecasting—field.

G. Physiologic specialistion—laboratory and pot experiment.

H. Multiplication of resistant types—field.

IV. Studies on new leaf drying disease of rice (pot and laboratory).

V. Soil microbiological studies with bacterial inoculants—laboratory and pots.

VI. Viability of culture in storage—laboratory.

VII. Studies on storage of rice and paddy (in collaboration with Entomology, Botany, Physiology and Chemistry)—Laboratory.

VIII. Studies on antibiotics—laboratory experiment.

IX. Search for perfect stage in nature.

X. Reaction of artificial mutants of pathogen.

XI. Effect of split application of N on disease resistance.

XII. Viability of pathogens in stubbles.

XIII. Protein synthesis and diseases incidence.

XIV. Marker genes culture to be tested.

Plant Physiology Division

1. Study of drought and saline resistance in rice.

2. Nutrition of rice.—The uptake and utilization of N, P and Iron by rice Plant.

3. Use of growth regulators and chelating agents in rice nutrition.

4. Photoperiodic response in rice as influenced by temperature and other factors.

5. Studies on seed viability, storage and after ripening in rice grains.

6. Development of laboratory techniques for screening varieties resistant to drought, salinity and flood conditions.

Blue Green Algae

1. Culturing of Algae.

2. Collection of representative specimens from different parts of India.

3. Inoculation of dried algae in field.

4. Setting up of laboratory—since the work has been initiated only this year after the Assistant Chemist joined, the laboratory has to be fitted according to requirements of the scheme.

Statistics Division

1. Field experiment on the positional effect of varieties—3rd year of the experiment.

2. Correlation and developmental studies (i) to study association between plant yield and its attributes, (ii) to study the growth behaviour of height of the plant, no. of tillers per plant etc.

3. Linkage studies—Development of formulae for the estimation of linkage in F_2 (cases of common genes are being considered).

4. Analysis of accumulated data.

5. Biometrical studies on quantitative inheritance.

Farm Division

1. Seed multiplication and Distribution.

2. Maximum potential experiment.

3. Trials of vegetatively propagated cultures of different cross combinations against the concerned parents.

4. Studies on the modified technique for rice culture.

5. Study on the effects of tractor ploughing in the low lying lands on the yield of transplanted rice.

6. Study of the economics of raising a crop by vegetative propagation.

7. Study of the economics of growing paddy by drilling, dibbling and transplanting.

Agricultural Engineering Division

I. Field experiments in wet land puddling :

(i) Efficacy of different bullock drawn puddlers:

(ii) Investigations and trials for the development of a multipurpose implement for green manure trampling and wet land puddling.

II. Field trials with push type manually operated harvester.

III. Testing of improved Agricultural implements in collaboration with the State Department of Agriculture.

IV. Studies in mechanisation of paddy cultivation.

V. Developmental of a plant splitter and single plant thresher for experimental use.

VI. Investigations on deep water structure in collaboration with Botany Division.

VII. Investigations on studies relating to water requirements of paddy in collaboration with Agronomy Division.

VIII. Investigations on paddy transplanter.

IX. Study of sowing methods in collaboration with Farm Division.

STAFF

Director	R. H. Richharia, M.Sc., Ph.D. (Cantab), F.B.S., F.R.S. (A).

Agronomy Division

Agronomist	M. V. Vachhani, B.Ag., Ph.D.
	I. C. Mahapatra, B.Sc.(Hons.) (Agri), Assoc. I.A.R.I. (from 1-5-61 to 27-8-61).
Research Officer in Agronomy	I. C. Mahapatra, B.Sc. (Hons.) (Agri), Assoc. I.A.R.I.
Research Assistant	M. S. Chaudhry, B.Sc. (Ag.), Assoc. I. A. R.I. (on deputation abroad from 25-12-59).
Research Assistant	M. V. Rao, B.Sc. (Ag.), (on leave from September, 1960).
Research Assistant	G. B. Manna, M.Sc. (Ag.)
Research Assistant	C. R. Padalia, M.Sc. (Ag.)
Research Assistant	A. C. Sharma, M.Sc.

Botany Division

Geneticist & Botanist	B. Misro, B.Sc., Assoc. I.A.R.I., M.Sc. (Lond.)
Cytologist	S. Sampath, M.A.
Assistant Botanist	S. Govindaswami, M.Sc., Ph.D.
Assistant Botanist	R. Seetharaman, M.Sc., Ph.D.
Research Assistant	C. N. Relwani, B.Sc.(Ag.)
Research Assistant	D. V. Seshu, M.Sc.
Research Assistant	C. Gangadharan, M.Sc.
Research Assistant	M. V. S. Sastry, M.Sc.
Research Assistant	N. K. Chau Patnaik, M.Sc.
Research Assistant	V. A. Kulkarni, M.Sc.
Research Assistant	A. Krishnamurty, M.Sc.
Research Assistant	J. Rama Krishna Rao, M.Sc.
Research Assistant	Miss. Alakamanjari Das, M.Sc.
Research Assistant	Prasenjit Jee Jachuck, M.Sc.
Research Assistant	G. C. Rath, M.Sc. (from 14-9-61).
Research Assistant	U. Prasada Rao, M.Sc. (from 4-10-61).

Chemistry Division

Soil Chemist	B. Bose, M.Sc., D.Phil. (upto 18-8-61).
Research Assistant	S. Patnaik, M.Sc., M.S.
Research Assistant	K. Janakiram, M.Sc.
Research Assistant	S. S. Roy, M.Sc.

Entomology Division

Entomologist	P. Israel, M.A., F.R.E.S.
Research Officer in Entomology	Y. S. Rao, M.Sc.
Research Assistant	V. Nageswar Rao, M.Sc.
Research Assistant	P. S. Prakasa Rao, B.Sc. (Hons.), M.A

Mycology Division

Mycologist	S. Y. Padmanabhan, B.Sc.(Hons.), M.A. Assoc. I.A.R.I.
Research Officer in Plant Pathology	N. K. Chakrabarti, M.Sc., D.Phil.
Research Assistant	G. H. Chandwani, B.Sc.(Ag.)
Research Assistant	J. Veeraraghavan, M.Sc.

Plant Physiology Division

Plant Physiologist	S. K. Majumdar, M.Sc. Ph.D.
Research Assistant	K. S. Murty, M.Sc. (Ag.) Ph.D.
Research Assistant	Ch. Narasinga Rao, M.Sc.

Blue Green Algae Scheme

Assistant Chemist . . .	M. N. Sahay, M.Sc., Ph.D. (London).
Research Officer in Agronomy .	L. L. Relwani, B.Sc. (Agri). Assoc. I.A.R.I.

Statistics Division

Statistician	A. K. Ghosh, M.Sc.
Research Assistant . . .	S. V. S. Prakasa Rao, M.Sc.

Farm Division

Farm Superintendent . . .	M. Subbiah Pillai, B.A., B.Sc. (Ag.)
Research Assistant . . .	N. A. Parasuram, B.Sc. (Agri.)

Agricultural Engineering Division

Agricultural Engineer . . .	M. L. Taneja, B.Sc. (Agri. Engineering).

Central Saline Rice Research sub-station, Port Canning

Research Assistant . .	P. N. Sreedharan, M.Sc.
Research Assistant . . .	T. E. Srinivasan, M.Sc.
Research Assistant . . .	V. K. Muralidharan, M.Sc.

Japonica × *Indica Scheme*

Assistant Botanist (Orissa) .	R. K. Misra, M.Sc.
Assistant Botanist (Mysore) .	B. K. Karibasappa, M.Sc., Assoc. I.A.R.I
Assistant Botanist (Madhya Pradesh)	D. V. Seshu, M.Sc.
Assistant Botanist (Kerala) . .	C. Gangadharan, M.Sc.
Assistant Botanist (Andhra Pradesh)	M. V. S. Sastry, M.Sc.
Assistant Botanist (Uttar Pradesh) .	M. J. Balakrishna Rao, M.Sc.
Assistant Botanist (Assam) . .	A. Krishna Murty, M.Sc.
Assistant Botanist (West Bengal) .	G. N. Mitra, M.Sc., Ph. D.
Assistant Botanist (Kashmir) .	P. N. N. Nambisan, M.Sc.

I.C.A.R. Scheme for Breeding Paddy Strains Resistant to Lodging

Research Assistant . . .	M. J. Balakrishna Rao, M.Sc.
Research Assistant . . .	Miss Suprava Mohanty.

Pilot Survey Scheme

Field Officer	P. M. Naha, M.Sc.
Field Supervisor . . .	K. V. S. R. Kameswar Rao, M.Sc.

CENTRAL RICE RESEARCH INSTITUTE, CUTTACK-4 (ORISSA)

NARRATIVE FINANCIAL ACCOUNTS UNDER REVENUE GRANT FOR INCLUSION IN THE ANNUAL REPORT FOR THE YEAR 1961

Sub-head	Year 1961-62		Remarks
	Final grant	Actual expenditure	
	Rs.	Rs.	
Main Institute Non-Plan & Plan			
Pay of officers	1,92,900	1,90,254	
Pay of Establishment	2,30,000	2,28,980	
Allowances & Honoraria etc.	80,500	75,599	
Other charges	2,88,000	3,08,642	
TOTAL (Plan & Non-Plan)	7,91,400	8,03,475	
I. C. A. R. Schemes (Plan)			
(a) Scheme for breeding paddy strains resistant to lodging.	13,750	12,824	
(b) Scheme for cytological, Anatomical and embryological studies on rice at C.R.R.I., Cuttack	9,200	9,150	
(c) Pilot Scheme for study of incidence of pests and diseases at C. R. R. I., Cuttack	40,180	37,377	
(d) Scheme for comparative efficiency on Ammonical and nitrate fertilizer on paddy	3,120	2,866	
TOTAL [I. C. A. R. Scheme (Plan)]	66,250	62,217	
GRAND TOTAL	8,57,650	8,65,692	

GIPN—S5—1 C.R.R.I. Cuttack/62—5-8-63—750

PRINTED IN INDIA BY THE MANAGER
GOVT OF INDIA PRESS NASIK 1963